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SDI: PROGRESS AND CHALLENGES

Staff Report Submitted To
Senator William Proxmire, Senator J. Bennett Johnston
and Senator Lawton Chiles

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EXECUTIVE SUMMARY

Since March, 1983, when the President set forth his vision of a space-based defense, which, in his own words, would "set us free from the prison of nuclear weapons," the United States has embarked on the most challenging, controversial and visionary defense program in its history. This staff study was conducted at the request of Senator Proxmire, Senator Chiles and Senator Johnston as the Strategic Defense Initiative nears its third anniversary. The report attempts to provide some perspective on the progress achieved to date in SDI and the challenges that lie ahead.

The findings of this study are:

- While some significant progress has been achieved in each of the five major programs of the Strategic Defense Initiative, none of it could be described as "amazing." Interviews with key SDI scientists involved in the research revealed that there have been <u>no major breakthroughs</u> which make a mid- to late-1990s deployment of comprehensive missile defenses more feasible than it was three years ago.
- In fact, the "schedule-driven" nature of the current research program, which requires that a development decision be made by the early 1990's, has aroused significant concern among scientists at the national weapons laboratories. The concern is twofold. First, promising long-term research will be compromised to reach an arbitrary schedule. Second, in an effort to maintain public support for high funding levels and an early development decision, SDI experiments will degenerate, in the words of a senior scientist at the Livermore National Laboratory, into "a series of sleazy stunts."

- Much of the progress that has been achieved has resulted in a greater understanding of program difficulties, which are much more severe than previously considered. Briefly, they are:

  -- The high-leverage, boost-phase defense faces considerable difficulties with survivability, which are greater than the obvious technical difficulties of developing operational weapons systems. A senior SDI researcher at the Sandia National Laboratory suggested that the technical problem of survivability was so intractable that the solution might well be a joint U.S.-Soviet space station to coordinate space-based defense efforts.

  -- If the boost-phase defense proves more challenging than expected, then the problems of midcourse discrimination of Soviet warheads from decoys will be both geometrically and qualitatively multiplied. The threat scenarios posed by the weapons labs are ten times as great and far more complicated than those generated by the Strategic Defense Initiative Organization (SDIO) in the summer of 1985.

  -- Passive discrimination of the midcourse threat may have little military utility. Possible Soviet countermeasures make passive discrimination by itself ineffective. Some progress has been made in research of a new type of discrimination -- interactive discrimination. At this point, however, interactive discrimination is little more than an interesting and promising concept.

-- SDIO is still assessing the findings of its Eastport Study on Battle Management and Computing, which was sharply critical of the planning priorities that went into the development of SDIO's selected systems architectures. If a dramatic shift in emphasis from systems hardware to battle management computing is required, current systems architectures might be irrelevant.

-- The shuttle tragedy pointed out current logistical difficulties with the deployment of space-based payloads. Unless fairly dramatic advances are made in U.S. space transportation, logistics and support capabilities, it may be impossible to begin deploying any SDI system until after the year 2000. This raises serious questions about the current schedules and emphases of the program.

- After three years, the SDI budget has nearly tripled. SDIO has slowed the pace of some of its research efforts; however, this has not been done primarily as a result of Congressional budget cuts, as SDIO officials have claimed. Decisions to downgrade certain research efforts seem to be driven as much by their lack of technical promise (as was the case with chemical lasers), and by SDIO's insistence on keeping to an unrealistic "technology-limited" research schedule.

- Public debate on the SDI has often centered on the desirability of performing a robust research program. The authors of this report consider that question moot. Public support for research is broad and bipartisan. The more relevant question involves the pace and direction of this program.

- SDI funding levels are as large as the combined services' technology-based research and development programs. The FY1987 budget request would more than quadruple the SDI budget in just four years. Despite the magnitude of this request, SDIO has yet to produce a definite set of systems architectures, which can be tested against a generated and realistic set of threat scenarios. In fact, there appears to have been no consensus reached on the range of threat scenarios these deployment options might be expected to face.

CONCLUSION

As a result of our extensive interviews and briefings conducted during the past two months with top SDIO officials, scientists and outside experts, this report comes to the following conclusions:

1. Congress should maintain a certain degree of skepticism over claims of tremendous advances in SDI research. Hard questions should be asked about what any so-called "spectacular breakthroughs" really accomplished and how far the research was actually advanced compared to the task at hand. So far, SDI has moved ahead by inches. We still have miles to go.

2. A closer look should be taken at whether boost-phase intercept can ever be made to work and whether space-based assets can ever be made survivable. If the evidence shows that boost-phase intercept cannot work and space-based assets cannot be made survivable, with or without arms control, serious questions should be raised about the feasibility of implementing the President's vision of a comprehensive strategic defense.

3. The problem of discriminating warheads from decoys in the midcourse phase of defense is much larger than Congress has been led to believe. SDIO is just scratching the surface in addressing this problem. Furthermore, it appears that there is no clear consensus on what kind of realistic threat strategic defense would face in the future.

4. Congress should be concerned about the priority shifts SDIO has made in its program. They appear to indicate that, contrary to public pronouncements, SDIO still does not have a firm idea of how a strategic defense system might be implemented. Nevertheless, Congress is being asked to pour billions of dollars into the program based on assumptions that the direction of the program is clear.

5. Congress should question why SDIO is rushing to arrive at a development decision by the early 1990's. Comprehensive ballistic missile defenses would not become fully operational until nearly two decades from now. Congress should be made fully aware of the serious risks involved in making a premature decision on whether to develop strategic defenses. Moreover, Congress should inquire as to whether additional time for research will result in a sounder development decision.

6. So far, Congressional debate over SDI has centered largely on its national security implications and on whether strategic defenses are militarily feasible. Much more scrutiny, however, must be given to whether it is feasible to produce, deploy and maintain such a system. It may well be that the production, transportation, support, logistics, and administrative requirements of a strategic defense system are as tremendous as the military and technical requirements.

7. A closer look should be taken at current and future U.S.-Soviet arms control regimes and their relationship with SDI.

Proposals to dismantle SALT, if implemented, would only make SDI's task more difficult. Abandoning the ABM Treaty now would only leave the Soviet Union with an advantage for the near-term in the deployment of hard-point defenses. The evidence indicates that further arms control constraints on the Soviet Union are necessary in order to make strategic defenses feasible. The question remains, however, whether an arms control regime can be established to make strategic defenses feasible.

8. After completing this review of the SDI research and the defensive systems being envisioned, we are struck by myriad uncertainties and unknowns at every turn in the program -- uncertainties and unknowns that bear directly on the effectiveness of a comprehensive ballistic missile defense we might deploy in the future. And much of that uncertainty will likely remain, for even with strategic defenses in place, the U.S. would never be able to adequately test the system under realistic conditions.

SDI supporters cite Soviet uncertainty as a rationale for deploying SDI. The Soviets would be deterred from attacking the U.S. because of their uncertainty over how well they could overcome U.S. defenses. However, if the Soviets deploy their own defensive system, which the President has invited them to do, then both they and we would likely be uncertain about the effectiveness of both our and their systems.

It would seem inevitable that faced with these uncertainties, both the U.S. and U.S.S.R. would deem it necessary to maintain a highly secure and effective antisatellite capability to ensure that at the onset of a nuclear conflict they did not suddenly discover their adversary's defense intact and their own defense debilitated. Thus, both sides would have strategic defenses in place with separate ASAT weapons poised to destroy the other's defense. This situation does not strike us as a stable environment for the future.

Furthermore, it is disturbing that despite a tripling of its budget the past three years, the SDIO has been unable or unwilling to develop any cost estimate for deployment and maintenance of a comprehensive strategic defense system. SDIO's statement that it will estimate what these defenses should cost is not enough. Congress needs to know what these defenses will cost.

9. Finally, this report has examined only the progress and challenges of SDI research. It leaves open any detailed examination of the question of whether strategic defenses are desirable even if some or many of the challenges can be overcome. As the point above makes clear, Congress should, nevertheless, begin a thorough consideration of that question.

Congress, therefore, may wish to consider four important questions this year:

- Can strategic defenses, particularly those intercepting ballistic missiles in the boost phase, be made survivable in the face of a future Soviet offensive threat and countermeasures?

• Can effective discrimination be achieved in the midcourse phase of defense to distinguish Soviet warheads from decoys, which, all told, may number in the millions during an attack?

• Why is it so important to make a development decision on the Strategic Defense Initiative by the early 1990's if that decision will be so fraught with risks?

• What will it cost not only to deploy comprehensive strategic defenses, but also to maintain such a system?

I. SCOPE OF THIS REPORT

At the beginning of 1986, because of your membership on the Defense Appropriations Subcommittee, you directed us to begin an intensive review of the Strategic Defense Initiative. In the six months preceding this review, senior officials in the White House, Department of Defense, and the Strategic Defense Initiative Organization had been quoted as saying that SDI had made tremendous progress the past two years. Adjectives such as "incredible" and "amazing" had been used by these officials to describe research breakthroughs SDI had been recently achieved.

The Strategic Defense Initiative has been designated a research program to determine the feasibility of a comprehensive ballistic missile defense system to shield both military and civilian targets. These so-called breakthroughs have been cited as evidence that SDI is feasible and that the unprecedented level of funding for this research program is justified.

This study was initiated at your request to learn more about the actual progress and changes made in SDI research, plus the challenges and problems that lie ahead.

We began by visiting and receiving extensive briefings at the following facilities conducting SDI research:

o U.S. Army Strategic Defense Command, Huntsville, Alabama. The Army, along with the Air Force, execute the largest portion of the SDI budget. USASDC conducts research into terminal defense for the SDI system (see Figure 1) and anti-tactical ballistic missiles suitable for a European defense.

o U.S. Air Force Space Division, Los Angeles, California. One of five divisions of the Air Force Space Command, the Space Division manages that service's execution of SDI research, concentrating on the boost phase, post-boost phase and midcourse defenses.

o Sandia National Laboratory, Albuquerque, New Mexico. Sandia is conducting research in threat technology, SDI systems analysis, directed energy weapons, discrimination technology, and space power.

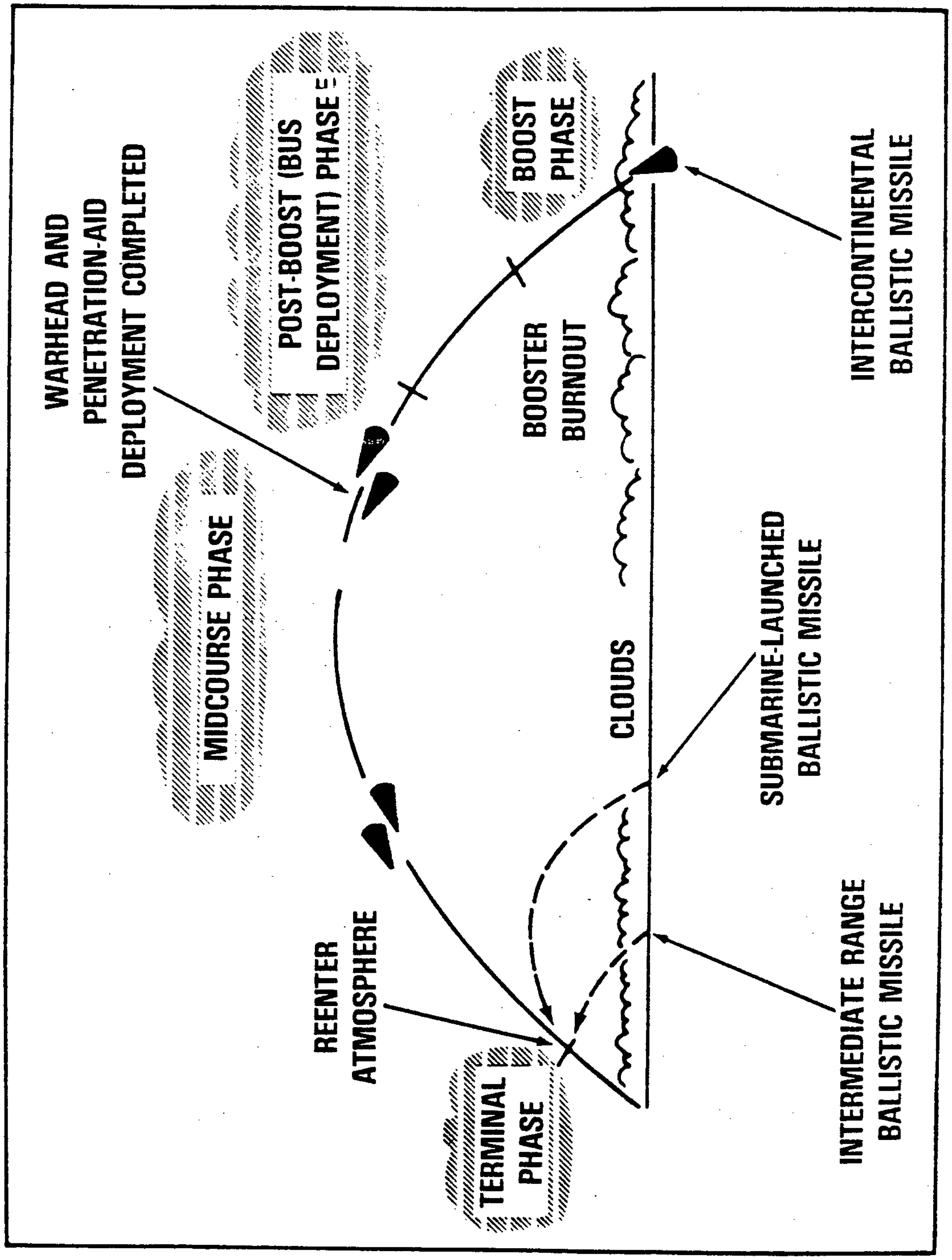
o Lawrence Livermore National Laboratory, Livermore, California. Livermore is conducting research in directed energy weapons such as the X-ray laser and free-electron laser, in threat analysis, and in super computers.

In addition to visiting major SDI facilities, we received briefings from SDIO Director Lt. Gen. James Abrahamson, SDIO's five program managers, its European strategic defense specialists, the General Accounting Office, the Defense Intelligence Agency and other scientists and ballistic missile defense experts.

The following report is not meant to be a comprehensive assessment of SDI research. Rather, it attempts to highlight what appear to be some key issues related to SDI's progress and problems,

Figure 1

MULTI-LAYERED



which Congress may wish to consider this year.

II. BACKGROUND

President Reagan's March 23, 1983, speech calling for a comprehensive scientific research effort to render nuclear weapons "impotent and obsolete" has opened the possibility for a major change in U.S. strategic doctrine. For three decades, the United States has relied on massive retaliation to deter a Soviet nuclear attack. The standoff has become known as mutual assured destruction (MAD).

From the late 1960's to the early 1970's, the United States, which had developed crude, nuclear armed missile interceptors from its air defense fleet, pursued the idea of ballistic missile defenses. The Soviet Union had also developed an interceptor missile system, known as Galosh.

By 1972, however, evidence mounted that an effective comprehensive ballistic missile defense system could not be deployed, that it would be too expensive, and that it would likely launch a dangerous offensive-defensive arms race. The Anti-Ballistic Missile Treaty was signed that year, sharply limiting ABM development and deployment on both sides.

Since entering into the ABM Treaty, the United States has still continued research into ballistic missile defense technology, concentrating on low-altitude nuclear-armed interceptors and non-nuclear exoatmospheric interceptors that might be deployed in a few years in response to a Soviet breakout of the ABM Treaty (see Figure 2). Some work was conducted in exotic technologies, such as lasers, which might have long-term applications; however, this research was scattered over a number of agencies and military services and lacked overall focus or direction.

All told, less than one billion dollars was spent annually on research into ballistic missile defense and related technologies in the years immediately before the President's public announcement launching his strategic defense research program, which has been dubbed his "Star Wars" speech.

While the United States saw no compelling economic or military justification for an ABM deployment as allowed for in the Treaty, the Soviet Union went ahead with deployment of a ring of Galosh interceptors around Moscow, which are currently being upgraded. The Moscow ABM system, which is based on technology the U.S. had developed at least 10 years ago, would be largely ineffective against a concentrated U.S. attack. Nevertheless, the Moscow ABM system does provide operational training for Soviet troops, which is not available for their U.S. counterparts.

The Soviets also have in place an extensive air defense network against aircraft and air-breathing cruise missiles, which some have

Figure 2

U S ARMY SDC

MILESTONES

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1955	FIRST CONTRACT
1957	FIRST MANAGEMENT OFFICE
1958	NIKE-ZEUS
1962	FIRST INTERCEPT
1963	NIKE-X
1968	SENTINEL
1969	SAFEGUARD
1971	HARDSITE DEFENSE
1972	ABM TREATY
1973	CONGRESS LIMITS DEPLOYMENT TO ONE SITE
1974	PROTOCOL TO ABM TREATY
1974	SAFEGUARD ERD
1976	SAFEGUARD CLOSED
1979	LOAD
1982	SENTRY
1983	DEFENSE IN DEPTH
1984	HOE
1985	

speculated could easily be converted to ABM defense. This capability, combined with an expansion of the current ABM system around Moscow "suggests that the U.S.S.R. may be preparing an ABM defense of its national territory," according to the Department of Defense's 1985 edition of Soviet Military Power.

Other intelligence estimates, such as the one provided by the CIA in unclassified testimony before the Defense Appropriations Subcommittee on June 26, 1985, do not come to the same conclusion, pointing to evidence suggesting that Soviet air defenses will not likely be associated with strategic defense and that the Moscow ABM system would not likely be expanded in the near term.

Furthermore, Soviet ABM interceptor rockets are nuclear tipped, making them more suitable for defending hardened military targets than cities. Military targets also would likely have priority in an expanded Soviets' missile defense. "It will be a long time before they (the Soviets) will do civilian defense," a Defense Intelligence Agency briefer told us. "It's not in their cards."

The Soviets also have conducted extensive research into laser and particle beam technology; however, U.S. intelligence analysts are vague and not unanimous in their assessment of how much progress the Soviets have actually made in this research and in advancing its military utility.

Before the President's March, 1983 speech, there was general agreement within the defense community and in the Congress that the United States needed to conduct some level of research in ballistic missile defenses as a hedge against a Soviet breakout or technological surprise and to explore emerging new technologies. To this day, among critics and supporters of the present Strategic Defense Initiative, there is general agreement that the United States should continue vigorous research into ballistic missile defenses.

It has also been widely acknowledged that funding for ballistic missile research needed to be increased from its 1970's level, which is exactly what the Administration, before the President's Star Wars speech, had planned to do. For example, the Administration had hoped to increase DoD's portion of strategic defense from $991 million in FY1984 to $1.5 billion and $1.8 billion in FY1985 and FY1986 respectively for a total of about $12.1 billion over five years (see Figure 3). Department of Energy spending for SDI-related activities was to total $1.8 billion for that same period.

Although there has been widespread support for a vigorous R&D program in ballistic missiles defenses for ICBM silos (to serve as a hedge against Soviet breakout of the ABM Treaty), there were few proponents within the military and scientific communities for a comprehensive defensive scheme to protect both military and civilian targets from Soviet attack. However, on March 23, 1983, President Reagan surprised most of the scientific and defense community by announcing that he was launching a national research effort with the "ultimate goal of eliminating the threat posed by strategic nuclear missiles."

Figure 3

PLANNED FUNDING FOR STRATEGIC DEFENSE

BEFORE THE PRESIDENT'S MARCH 23, 1983 SPEECH

($million)

	FY84	FY85	FY86	FY87	FY88	FY89
Army	508	992	1,105	1,325	1,493	1,519
Navy	12	15	8	8	11	2
Air Force	146	195	348	440	722	929
DARPA	302	305	316	382	447	501
DNA	17	20	25	26	26	31
Total DoD	991	1,527	1,802	2,181	2,699	2,982
DoE		210	295	365	439	505
Total		1,737	2,097	2,546	3,138	3,487

Source: SDIO data.

The President's Star Wars speech touched off an intense debate in the defense and arms control community over the role of ballistic missile defense in U.S. national security strategy. During the first two years of SDI research, there have also been deep divisions within the scientific community over the feasibility of such defenses.

In addressing the question of SDI's feasibility, three points should be kept in mind. First, the charter of the Strategic Defense Initiative Organization (SDIO) directs it to conduct research to determine the feasibility of an effective ballistic missile defense. Neither the SDIO charter nor the SDI research effort itself is aimed at making nuclear weapons obsolete. It could not do so even if that were its aim. To make nuclear weapons obsolete would necessitate an absolutely perfect defense against all Soviet aircraft and cruise missiles, as well as against ballistic missiles. As the Future Security Strategy Study (the Hoffman Panel) noted, "pursuit of the President's goal... will raise questions about our readiness to defend against other threats, notably that of air attack by possible advanced bombers and cruise missiles. An appropriate response to such questions will require an early and comprehensive review of air defense technologies, leading to the development of useful systems concepts." An appropriate response also would require countering other means of delivering nuclear weapons -- smuggled in by trawler, sneaked across the border in a suitcase, etc.

Second, during our briefings by General Abrahamson and his program managers, there was never any discussion of an impenetrable defense shield against ballistic missiles that would protect all Americans from nuclear war. Rather, the SDI program is aimed ultimately at creating successive layers of ballistic missile defenses, effective enough as a whole to deter the Soviets from attacking in the first place. General Abrahamson made it quite clear that the objective of SDI is deterrence.

President Reagan also has emphasized this point. In a press interview last year, the President said: "I've never asked for 100 percent. That would be a fine goal, but you can have a most effective defensive weapon even if it isn't 100 percent, because what you would have is the knowledge that -- or that the other fellow would have the knowledge that if they launched a first strike, that it might be such that not enough of their missiles could get through, and in return we could launch the retaliatory strike... If SDI is, say, 80 percent effective, then it will make any Soviet attack folly. Even partial success in SDI would strengthen deterrence and keep the peace."

In other words, with or without SDI, Soviet fear of our offensive force will remain the bulwark of U.S. deterrence.

Third, the feasibility of a comprehensive ballistic missile defense must be considered against very specific and demanding criteria, applied not just to individual weapons technologies, but to the system as a whole. These criteria include the system's affordability, its survivability, and the future Soviet threat. There is no doubt that the United States could build some type of anti-ballistic missile system today that would be of limited effectiveness against a Soviet nuclear attack. However, a comprehensive strategic defense is an entirely different question and the criteria against which it will be measured are considerably more challenging. They are crucial nonetheless. A comprehensive ballistic missile defense will not prove to be feasible if they are not met.

In the fall of 1985, however, senior Administration and DoD officials began making optimistic assessments of SDI's feasibility, asserting that substantial progress in the program had allayed many of the concerns that had been raised by outside critics. These comments came shortly after the Reagan-Gorbachev summit in Geneva.

General Abrahamson, for example, was quoted in The New York Times as saying that SDI's critics now consisted of "only a few diehards left, sincere diehards, but only a very few, who still say this doesn't make sense, or who ask why we should do this to begin with... The question is no longer can we do such a thing, but when, how fast and at what cost." Using phrases such as "incredible" and "genuine breakthroughs," General Abrahamson claimed, according to press reports, that recent experiments have exceeded the program's most ambitious expectations.

Secretary of Defense Caspar Weinberger has been quoted as saying SDI is "making much greater progress than we anticipated. The barriers we saw to progress are crumbling."

Then-White House science adviser George A. Keyworth II told The Washington Times, "There have been monumental breakthroughs that have made us far more confident 2 1/2 years later than we projected even in the optimistic tone that was evident in the original (SDI) speech." Keyworth went on to claim that the U.S. will be able to demonstrate the technical feasibility of a laser-based ABM system "if not in Ronald Reagan's tenure, then very shortly thereafter... Whoever is president in the early 1990's will have... sufficient information to think seriously about deployment."

Keyworth's statement suggested even more progress in SDI research than claimed by General Abrahamson and Secretary Weinberger. In the past, SDIO had reported that it would be able to provide adequate information to make a development decision by the early 1990's -- that is, a decision on SDI's feasibility and on whether to begin development of the weapons. A deployment decision would come later. Keyworth, however, seemed to indicate that SDI research had progressed so rapidly, the development decision might be made before the end of President Reagan's term and the deployment decision might be made in the early 1990's.

In addition to numerous public statements, SDI officials released results of recent experiments (along with photos and film), to demonstrate that substantial progress had been made in the research. These releases, for example, included videotapes of a chemical laser shooting through the skin of a stationary mockup of a Titan booster and what was reported to be a railgun destroying a missile airframe under simulated flight loading conditions.

III. SDI BUDGET TRENDS

Following the President's March, 1983 speech, the Defensive Technology Study Team (the Fletcher Panel) was established to define a long-term research and development program aimed at eliminating the threat posed by ballistic missiles.

In January, 1984, Secretary Weinberger established a research program based on the Fletcher study -- the Strategic Defense Initiative. Furthermore, the Fletcher study laid out a general blueprint for a "technology-limited" research program, which largely became the basis for SDI's budget submissions for FY1985 and FY1986.

Strictly defined, a technology-limited program is limited only by technological progress. The Fletcher study recommended that all aspects of SDI research proceed at a pace as fast as the technology would allow, so a future Administration and Congress could make a decision by the early 1990's as to whether strategic defenses are feasible and should be developed. On the other hand, a funding-limited program is limited by the funds appropriated. As such, priorities have to be set on the pacing of individual aspects of the research.

SDI requested $1.78 billion for FY1985 and $3.72 billion for FY1986. For FY1987, SDI has requested $4.8 billion, which would make it the largest major weapons program in the entire DoD budget. SDI also has projected a total cost for the research phase of about $33 billion between FY1985 and FY1990, more than double the predicted funding before the President's March, 1983 speech. (This figure does not include the hundreds of millions of dollars funded in the Department of Energy for strategic defense-related research. See Figure 4 for a description of SDI and DoE's funding.)

SDI will be the largest military research program the Department of Defense has ever undertaken. The research alone will be in excess of the full deployment costs of many major weapons systems. Moreover, at its current level of funding SDI is as expensive as the total technical base efforts of all the armed services.

SDI officials have avoided placing a price tag on deploying a comprehensive defensive shield. Outside experts, such as former defense secretary James Schlesinger, have predicted that a full development and deployment of strategic defense would cost as much as $1 trillion.

SDI officials, insisting that the $1 trillion estimate is too high, say it is too early in the research for accurate forecasts of deployment costs. Rather than give an estimate of SDI's total cost based on current information, General Abrahamson said he is working to develop what SDI <u>should</u> cost if it is to be affordable and meet the cost-effective-at-the-margin criteria, as posed by Ambassador Paul Nitze. Within a year, the SDI organization hopes to begin establishing "cost objectives" for its weapons -- for example, $1 million for a ground-based intercepter, according to Abrahamson.

Figure 4

STRATEGIC DEFENSE FUNDING
($million)

Strategic Defense Initiative Organization

Program	FY1985	FY1986	FY1987	FY1988
Surveillance, Acquisition, Tracking & Kill Assessment	545.950	856.956	1,262.413	1,558.279
Directed Energy Weapons	377.599	844.401	1,614.955	1,582.037
Kinetic Energy Weapons	255.950	595.802	991.214	1,217.226
Systems Concepts & Battle Management	100.280	227.339	462.206	563.998
Survivability, Lethality & Key Support Technology	108.400	221.602	454.367	523.654
Management HQ, SDI	9.120	13.122	17.411	18.118
Total	1,397.299	2,759.222	4,802.566	5,463.312

Department of Energy

	FY1985	FY1986	FY1987
Strategic Defense-Related Programs	224	288	603

Nevertheless, SDI officials appear to be privately making preliminary estimates of deployment costs based on information accumulated so far. For example, one official projected that a particular defensive architecture (the configuration of weapons in a defensive shield) would cost $350 billion to deploy.

Whatever the final cost, it is clear that the present SDI program is not being funded at the pace the Administration had originally envisioned. As noted above, SDIO has submitted what it considered a technology-limited budget to Congress the past two years. Congress, however, has approved a more funding-limited approach.

In FY1985, the Administration requested $1.78 billion for SDI, but Congress appropriated $1.4 billion. For FY1986, SDIO requested $3.7 billion, but received $2.76. Figures 5 and 6 shows where the major reductions were achieved for FY1986.

Actually, it is not accurate to argue that Congress has ever cut SDIO's budget. In fact, Congress allowed SDIO's budget to increase by 41 percent for FY1985 and 92 percent for FY1986. Reductions have occurred only in the sense that the Congress refused to make the increases as large as the Administration requested. In fact, Congress has allowed almost a <u>tripling</u> of the SDI budget since 1984.

It is also interesting to note that, according to SDI documents, a majority of the cuts were taken in demonstration projects, which some critics of the program have worried are moving too far ahead of other, more important research efforts. However, two even more important trends appear as result of recent funding shifts in the SDI program.

First, the Fletcher budget is not the budget SDI now has, yet SDI is still clinging to the Fletcher Panel's timeline.

As noted above, the Fletcher Panel proposed a technology-limited program, in which every research project was funded as heavily as it could be carried forward, so a decision on whether to develop strategic defenses could be made in the early 1990's. It is not clear whether even with a technology-limited budget and unlimited funding, SDIO could have made a sound development decision by that date. However, in the absence of unlimited funding, SDIO's managers faced two choices.

They could continue to carry every research project forward, which, under a funding-limited program, would mean that the early 1990's development decision might be pushed to a later date. Or they could set priorities in the program -- that is, slow down some projects, speed up others -- in order to attempt to reach a development decision by the early 1990's.

SDIO has chosen the second option. It is making choices between competing research projects and yet it is keeping to the same timeline of reaching a development decision in the early 1990's. SDI officials, however, candidly admit that there will now be

Figure 5

MAJOR FY86 REDUCTIONS

($M)	REQUEST	REDUCTION	BUDGET	IMPACT
SENSORS				
BSTS	131	−32	99	CANCELS SUPPORT TECHNOLOGY DEMO
SSTS	129	−53	76	CANCELS COMPREHENSIVE FLIGHT EXPERIMENT
AOA/AOS	191	−68	123	DELAYS AOS 1 YEAR
TIR	75	−45	30	DELAYS PROGRAM 1 YEAR
OPTICAL MEASUREMENTS	199	−77	112	DELAYS PROJECTS 1 YEAR
IR TECHNOLOGY	151	−71	80	ELIMINATES PARALLEL TECHNOLOGY
SIGNAL PROCESSING	192	−86	106	ELIMINATES PARALLEL TECHNOLOGY
DEW				
LASER TECHNOLOGY	195	−82	113	SEVERE CUTS IN EXCIMERS, CHEMICAL LASERS & RF LINAC
BEAM CONTROL TECHNOLOGY	201	−85	116	MAJOR CUTS IN ATMOS COMPENSATION, OPTICAL COMPONENTS
ATP	114	−63	51	GBL MIRROR CUTBACK

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Figure 6

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MAJOR FY86 REDUCTIONS

($M)	REQUEST	REDUCTION	BUDGET	IMPACT
KEW				
ERIS	159	−73	86	VALIDATION TESTS OF CRITICAL COMPONENTS ONLY
HEDI	299	−183	116	SLIP OF 9-12 MONTHS
RAILGUNS	157	−77	80	MAJOR CUT OF TECHNOLOGY
SYSTEMS & BM/C3				
SYSTEMS	98	−18	80	REDUCED LEVEL OF ARCHITECTURE ANALYSIS
BM/C3 TECHNOLOGY	108	−27	91	TECHNOLOGY DEVELOPMENTS DELAYED
SURV/LETH				
SURVIVABILITY	72	−9	63	1 YEAR DELAY IN KEW SHIELD
LETHALITY	104	−12	92	HYPER VELOCITY TEST FACILITY CANCELLED
SPACE POWER	64	−6	56	DOWNSCOPES MULTIME GAWAIT
SPACE LOGISTICS	19	−8	11	REDUCES INVESTMENT IN LOW COST TRANSPORTATION

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significantly more risks associated with that development decision as a result of not all the technologies coming on line by that time. General Abrahamson, for example, spoke of the "risks" incurred as the timeline for experiments slips and as "early" technical decisions are made. The implications of this strategy and its risks will be considered later in this report.

The second trend now evident is that SDI's research priorities are substantially different from the ones proposed by the Fletcher Panel and from the ones made when the FY1986 budget request was submitted early last year.

SDIO officials claim that Congressional budget cuts were to blame for the shifts in priorities. Indeed, a few of the shifts were prompted by budgets cuts. However, it is clear that some cuts were prompted by a realization that some of the research projects would not prove militarily useful. SDIO has discovered that many of the research projects the Fletcher Panel gave high priority based on the body of knowledge available at the time, did not in fact merit such priority.

Again, it is interesting to note that these were many of the same projects, which critics had contended were overfunded. The priority shifts will be addressed further in this report. (See Figure 7 for instances where actual funding has been increased for research projects above the President's FY1986 budget request.)

IV. PROGRESS BEING MADE IN SDI RESEARCH

We believe that the SDI organization is justified in claiming that progress has been made the past two years in its research. One should not expect otherwise, considering the large increase in funding for the research. Clearly, in a very short time, the Department of Defense has organized a vigorous, centrally directed program that is conducting research at a quickened pace.

Furthermore, this research is focused on reaching a conclusive decision by the early 1990's. Statements from SDI officials that, "This is just a research program at this stage," are not entirely accurate. SDI is not a research program by the traditional notion of one that simply explores new technologies. It is a program aimed at reaching an early decision on what kind of defensive system the U.S. could develop in the early 1990's and then deploy. The research, therefore, is being driven not necessarily for exploration's sake but rather by that schedule.

The merits of schedule-driven research to arrive at an early decision will be discussed further. For the moment, it should be noted that progress has been made in SDI research by the very fact that its projects have been consolidated under one organization.

Before SDI, each military service had its own missile defense research program. In addition, various DoD agencies pursued research

Figure 7

MAJOR FY86 ADJUSTMENTS

($M)	REQUEST	ADJUSTMENT	BUDGET	NEW EMPHASIS
DEW				
GBL	27	+40	67	ACCELERATES FEL
NPB DISCRIMINATION	0	+73	73	INITIATES MID-COURSE DISCRIMINATION EXPERIMENT
X-RAY	10	+95	105	ACCELERATES X-RAY LASER RESEARCH
KEW				
SBKKV	200	+20	220	INITIATES EARLY EXPERIMENT
SYSTEMS/BM&C^3				
BM/C^3 EXPERIMENTAL SYSTEMS	9	+11	20	ACCELERATES BM/C^3 EXPERIMENTS

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into individual aspects of BMD. As a result U.S. BMD research has lacked a centralized approach.

By bringing together 25 BMD-related programs from the Army, Air Force, Navy, Defense Nuclear Agency, and Defense Advanced Research Projects, SDI has give strategic defense research much more direction and control. While this study uncovered complaints from the executing agencies about SDI's management, it is generally conceded that the BMD research has more potential for success by having one organization supervising it.

The facilities visits and briefings conducted for this report revealed that numerous research projects under SDI have demonstrated significant progress during the past two years. There is a high degree of professionalism, enthusiasm and expertise among the scientists and military planners working in the national laboratories and military facilities. There is also a healthy amount of skepticism among these researchers. Hard questions are being asked of SDI and the research teams are working intensely to find the answers.

For example, Livermore Laboratory is making progress in its research on a free electron laser. Although Livermore faces significant hurdles in developing technologies for a battle laser, this research is moving in the direction of developing shortwave-length lasers with some military capability. Livermore's work on X-ray lasers has also shown progress, despite considerable scientific debate over what strategic defense mission such a weapon might perform.

Recognizing that passive sensors will have difficulty discriminating warheads from decoys, Sandia Laboratory's research into the concept of interactive discrimination appears promising. Indeed, it may turn out that particle beam or laser technology will be more valuable as discriminators rather than weapons. Sandia also is making significant progress in defining potential Soviet countermeasures and the survivability requirements for a U.S. defensive system.

In other instances, according to General Abrahamson, SDI researchers have identified areas where the technical requirements for the particular system will not be as stressing as once thought. For example, the original requirement placed on the Boost Surveillance and Tracking System was to track Soviet missiles as they are launched. SDI has now downgraded that requirement so BSTS only has to act as a sophisticated "bell-ringer" to let the system know an attack is under way. The difficult task of boost-phase surveillance and tracking has been largely handed over to the Space Surveillance and Tracking System (SSTS).

The SDI organization also has made progress in identifying both research that they believe will not likely have much military utility and the research that is more critical to the success of a strategic defense system. SDI briefers avoid straightforward statements that certain research is being de-emphasized because it lacks military utility. Nevertheless, it is clear SDI now believes that certain research projects, such as space-based chemical lasers or hypervelocity launchers, are lesser candidates at the moment. SDI officials also recognize that progress in certain research, such as survivability of space-based assets and midcourse discrimination, is critical to an effective defense (although publicly SDI directors hedge as to how critical they are).

Finally, it appears that a number of small projects among the 1,000-2,000 contracts SDI has let so far have yielded results. From tiny gyroscopes to computer chip technology, a number of ideas and innovative technologies have surfaced from universities and small businesses as a result of SDI.

Success, however, in one small project -- or hundreds of projects, for that matter -- does not necessarily make for a successful strategic defense program. The task at hand and the hurdles it faces are so exacting that the sum of research cannot be judged solely by its parts.

Any meaningful assessment of SDI research, therefore, has to be made of the program in its entirety. In other words, the bottom-line question is: Overall, what kind of progress has SDI made in its research? What do all the individual research projects and initiatives add up to?

Has SDI made amazing progress, as senior Administration officials have recently claimed? Have there been tremendous breakthroughs? Has SDI research advanced so dramatically that the question of strategic defense's technical feasibility is already settled?

After interviewing more than 40 scientists, engineers, defense experts and military officials deeply involved in SDI's research, the authors of this study have concluded that the simple answer to the questions above is: no. Granted, each person interviewed for this study spoke from his own perspective. The authors took into account that many of the briefers specialized in only parts of SDI research and therefore could not speak for the entire program. Nevertheless, taken together their assessments lead us to the conclusion that SDI research has not progressed nearly as rapidly as has been portrayed by senior Administration and SDI officials.

Contrary to press reports, there have been no incredible breakthroughs in SDI research the past six months. There has been progress, to be sure. But key SDI scientists interviewed for this study agreed that their results were not as spectacular as has been portrayed to the media. If anything, these working scientists resented the fact that the progress their research has achieved has been inflated, because it undermines their credibility as scientists. As one researcher said, the hyping of the progress "is driving good people out of the program."

There have not been amazing leaps in the technology development. Contrary to claims by Administration officials and SDI's top leadership, the program's scientists and military planners across the country have <u>not</u> concluded that SDI is militarily and economically feasible. They presently have little idea whether it is. The fact is, they are still assembling the research to ask and answer the right questions.

If anything, the dramatic progress SDI has achieved during the past two years has been in identifying the operational problems a strategic defense system would face.

The research being accumulated by SDI clearly indicates that the technological hurdles are much greater, the possible Soviet offensive threat and countermeasures would be much more formidable, and the logistical and battle management difficulties are much more complex than originally envisioned. (Figures 8 and 9, for example, summarize some of the hurdles as some scientists at the Sandia Laboratory presently see them.)

What follows is an assessment of two major emerging problems for SDI, which its researchers are just beginning to understand.

V. TWO MAJOR EMERGING PROBLEMS

A. Making The Boost-Phase Effective

SDI's leadership believes that destroying Soviet missiles in their boost phase -- that is, during the first few minutes after launch while the boost rocket is still firing and is easy to detect from space and before the missile dispenses its bus of warheads -- is the most important opportunity for thinning out the Soviet offensive force. Because of the short attack times involved and the launch locations, a boost-phase defense means having space-based platforms firing rockets, projectiles, or directed energy weapons at the rising booster rockets or relaying a laser beam fired from the ground.

General Abrahamson made it clear in his briefing that the boost-phase intercept simply has to work. While not impossible to achieve, a strategic defense without the boost-phase would make the entire defense much more costly and complicated. "We need the boost phase," Abrahamson emphasized. The briefing charts he and his program managers presented stated over and over again, for example, that, "Performance of the boost phase intercept tier is critical," or "Low-leakage, boost-phase intercept is essential."

Furthermore, it appears that President Reagan, in conceiving his proposal for a strategic defense, recognized the need for a boost phase defense. In a press interview, the President noted that in formulating his proposal one of the first questions he posed to the Joint Chiefs of Staff was whether "it would be worthwhile to see if we could not develop a weapon that could perhaps take out, as they left their silos, those nuclear missiles. And the Joint Chiefs said that such an idea, they believed, was worth researching."

From its inception SDI has been primarily billed by the President as a nonnuclear defense of populations, which would make nuclear weapons impotent and obsolete. Some argue that this would require the

Figure 8

Sandia National Laboratories

STRATEGIC DEFENSE IN A NUTSHELL

- Boost Phase
  - Might be Feasible if Survivable
  - If not Survivable, Depend on Midcourse and Terminal
- Midcourse Phase
  - Might be Feasible if Discrimination is Solvable
  - If not, Depend on Boost and Terminal
- Terminal Phase
  - Overwhelmed without Boost or (and?) Midcourse for Population Defense
  - Maybe can Stand Alone for Hard Target Defense

Figure 9

THE DEMANDS ON A SATISFACTORY DEFENSIVE SYSTEM ARE SEVERE

- ARMS-RACE STABILITY
  - COST EFFECTIVE
  - ASSURED AND EQUAL CAPABILITY
    - SINGLE, CO-OPERATIVE SYSTEM
  - POLITICALLY EFFECTIVE
    - ASSURED EFFECTIVENESS
      - TESTABLE AND PROBABLE
      - BI-LATERAL

- CRISIS STABILITY TCHNICALLY EFFECTIVE
  - LETHAL (FLAMING WRECKAGE)
  - NON-SATURABLE
    - COST EFFECTIVE
  - ANTI-ICBM AND ANTI-SLBM
    - GLOBAL COVERAGE
      - SPACE BASED
  - ANTI-FAST-BURN BOOSTER
    - SPACE BASED
    - SOME ATMOSPHERIC CAPABILITY
    - AUTOMATIC
  - SURVIVABLE
    - SELF-DEFENDING
    - AUTOMATIC
    - CO-OPERATIVE SINGLE SYSTEM
      - RESTRICTED USE OF SPACE

TFF1000.09

deployment of a leak-proof shield. SDI's supporters, as previously noted, respond that an effective defense generally defined in the 80 percent or higher range would provide the United States with the technological leverage to deter a Soviet missile attack and to move the U.S.S.R. away from further development of what the President has referred to as the "fast movers" -- the intercontinental ballistic missiles (ICBMs).

On its face, the argument for technological leverage has some appeal. However, such technological leverage still requires the deployment of a layered defense at least 80 percent effective. (The requirement could be and probably is much higher.)

To achieve that kind of capability and leverage, it appears critical that the boost-phase defense layer must work. It is in those first few minutes of missile flight before the buses dispense their warheads that the strategic defense can exercise its greatest control. Once the warheads have been dispensed, the problems of strategic defense increase geometrically and the advantage gradually shifts to the offense.

There appears, however, to be some disagreement developing over the importance of the boost-phase and this disagreement may well prove central to the debate over the future feasibility of SDI.

One of the systems architecture designs SDIO has been presented envisions no space-based, boost-phase intercept at all. Instead, ground-based, pop-up interceptors and directed energy weapons would attack during the post-boost and midcourse phases (they could not be popped up quickly enough to attack during the boost-phase). Some SDI scientists feel that if a space-based, boost-phase intercept system cannot be deployed, it does not necessarily mean the strategic defense will not work. They believe that a strategic defense might be successful if it operated only in the midcourse and terminal phases. (Figures 10-13 depict boost-phase, midcourse and ground-based defense schemes).

There is one very significant problem, however, with an affordable, nonnuclear strategic defense that just relies on the midcourse and terminal layers. That problem -- one of the very "long poles" in the SDI tent -- is the discrimination of a <u>proliferated</u> Soviet offensive threat during the midcourse phase.

1. Discrimination

With the successful demonstration of the 1984 Homing Overlay Experiment, in which a ground-based missile intercepted a reentry vehicle in space, the Army demonstrated that "a bullet could hit a bullet." However, that accomplishment, as significant as it was, pales in comparison with the tremendous problem of the bullet finding the real bullet.

That problem is called discrimination and target acquisition -- distinguishing the Soviet warheads from the decoys -- and in the midcourse phase of defense it is the critical technological hurdle SDI

Figure 10

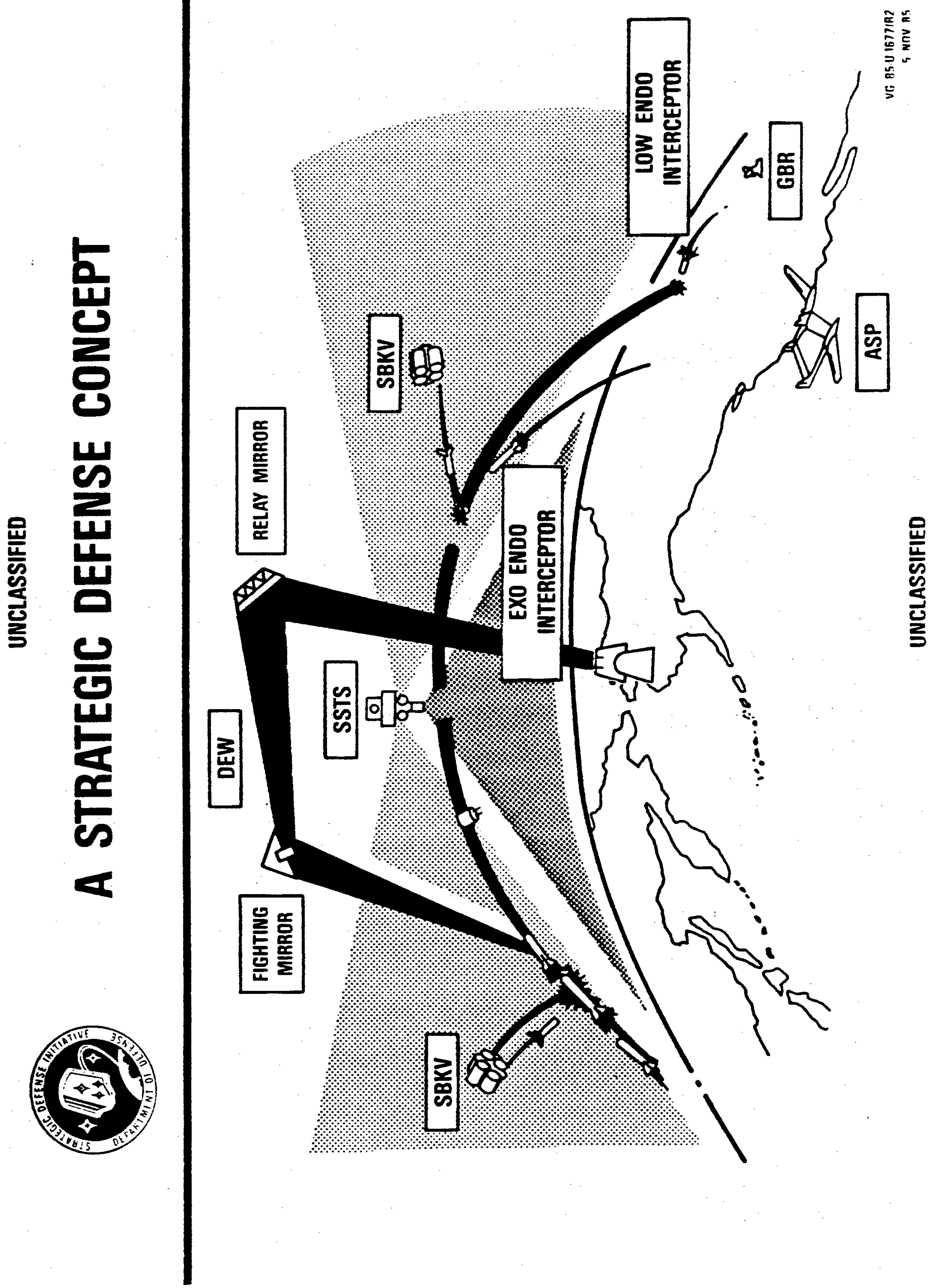

UNCLASSIFIED
A STRATEGIC DEFENSE CONCEPT
STRATEGIC DEFENSE INITIATIVE
DEPARTMENT OF DEFENSE
SBKV
FIGHTING MIRROR
DEW
SSTS
RELAY MIRROR
SBKV
EXO ENDO INTERCEPTOR
LOW ENDO INTERCEPTOR
GBR
ASP
UNCLASSIFIED
VG 85-U 1677/R2
5 NOV 85

Figure 11

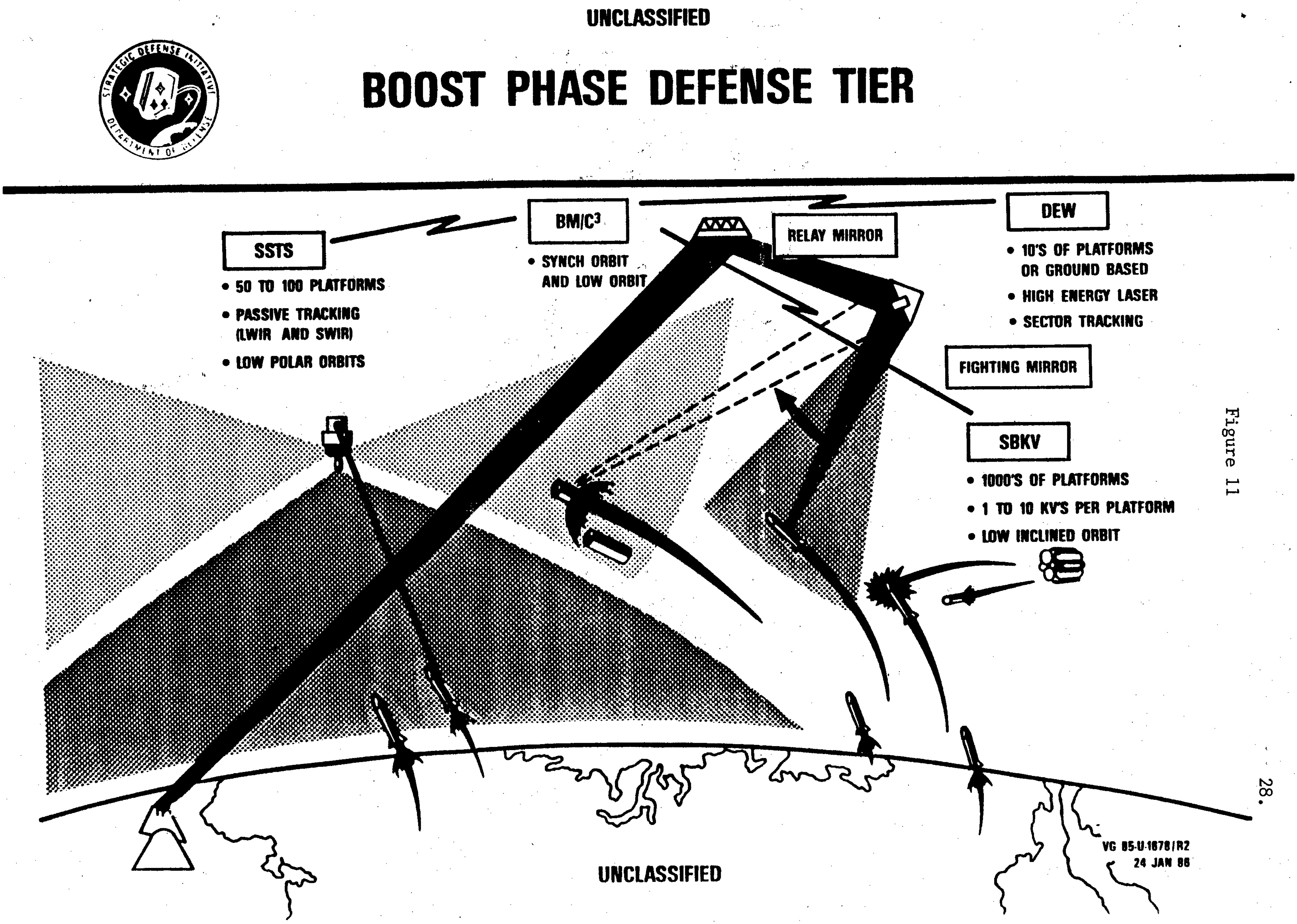
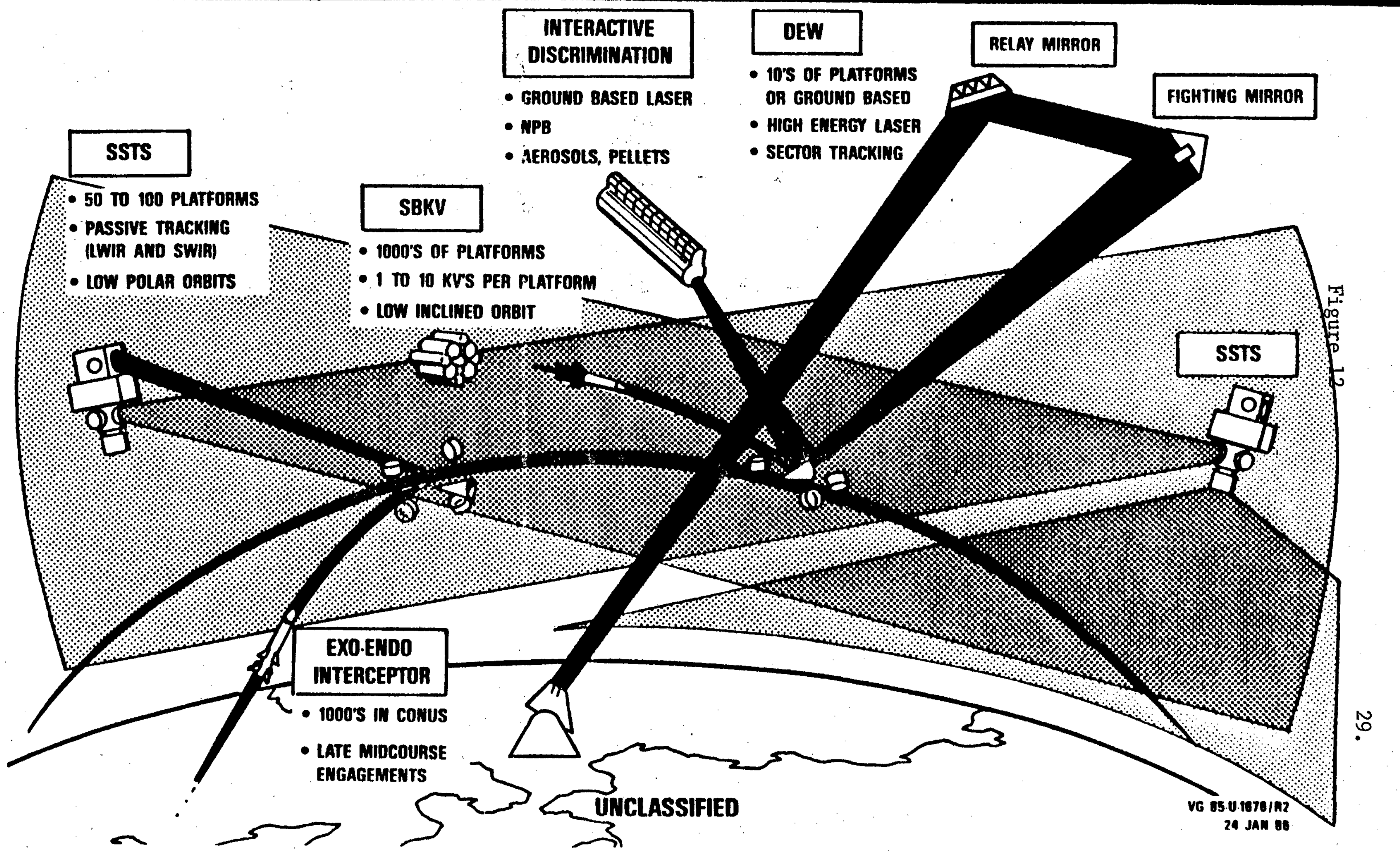

UNCLASSIFIED
BOOST PHASE DEFENSE TIER
SSTS
• 50 TO 100 PLATFORMS
• PASSIVE TRACKING (LWIR AND SWIR)
• LOW POLAR ORBITS
BM/C3
• SYNCH ORBIT AND LOW ORBIT
RELAY MIRROR
DEW
• 10'S OF PLATFORMS OR GROUND BASED
• HIGH ENERGY LASER
• SECTOR TRACKING
FIGHTING MIRROR
SBKV
• 1000'S OF PLATFORMS
• 1 TO 10 KV'S PER PLATFORM
• LOW INCLINED ORBIT
UNCLASSIFIED
VG 85-U-1678/R2
24 JAN 86

Figure 12

UNCLASSIFIED

MIDCOURSE DEFENSE TIER



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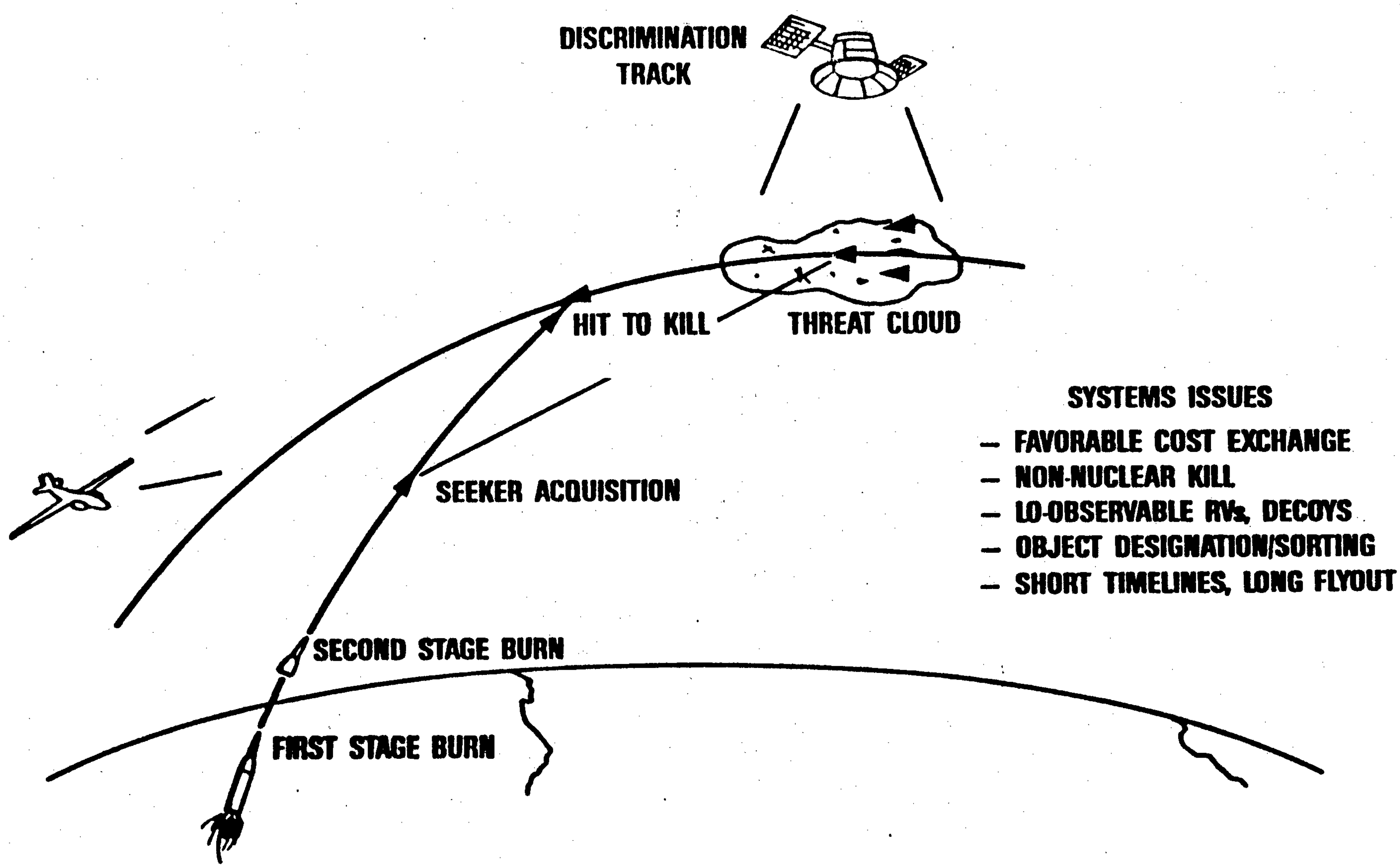
VG 85-U-1876/R2
24 JAN 86

Figure 13

GROUND-BASED EXOATMOSPHERIC INTERCEPT CONCEPT (U)



officials believe they face. Of course, strategic defense planners could simply not worry about discrimination in the midcourse and shoot at everything in the threat cloud. This option, however, does not appear promising at the moment, particularly in the face of a huge threat cloud of warheads and decoys. Therefore, SDI officials have said they will have to look toward discrimination in this phase of the defense.

The midcourse discrimination hurdle has two aspects, according to one Sandia scientist: numbers and There may be too many warheads and decoys, and the warheads may be indistinguishable from decoys.

a. Proliferated Threat

First, consider the numbers. During the past two years, every new SDI assessment of Soviet capability to place warheads and decoys in space appears to be different from the previous one in the following respect: The latest assessment invariably deems the Soviets substantially more capable than the previous assessment.

For example, in the early days of SDI, its researchers claimed the Soviets would only be capable of producing a threat cloud of tens of thousands of warheads and decoys. SDI officials also insisted that development of fast-burn boosters to stress boost-phase defenses would degrade the Soviet capability to increase its threat cloud.

In FY1985, that assessment changed somewhat. Sandia scientists reported that fast-burn boosters would not necessarily degrade the weight that could be lifted into space. Furthermore, SDI's systems researchers began projecting that the Soviets might be capable of placing in space a threat cloud numbering
and decoys.

The briefings received for this study, however, revealed an even more ominous picture of Soviet capability to stress midcourse discrimination.

Furthermore, Livermore's scientists have concluded that fast-burn boosters would not necessarily degrade Soviet capability to put warheads and decoys in space; as a matter of fact, Soviet fast-burn boosters might even be able to dispense several mini-buses of warheads (instead of a single bus, as is now done), which would further complicate the post-boost-phase defense.

The first step in discrimination is assembling data on the actual Soviet RVs and using that information as benchmarks for detecting decoys. Decoys obviously would have different physical characteristics than warheads. But in order to tell the differences between a speeding decoy and a speeding warhead one first has to know what the speeding warhead looks like. At this point, however, the U.S. is only beginning to collect the midcourse discrimination information it needs on the Soviet warheads themselves, because there are so many varieties. Keep in mind, what the U.S. sees today in Soviet RV test flights, might be different from what it sees in war (see Figure 14 for the Soviet view of deceptive test data). Meanwhile, the Soviets are presumed to have a better data base on U.S. warheads because ours are more similar to each other.

Because of the types of decoys the Soviets might use to deceive the defense and the nuclear environment they might create by detonating warheads in space, SDI scientists and General Abrahamson himself have concluded that passive discrimination alone will not be effective in the midcourse phase. (Passive discriminators, such as infrared sensors, attempt to identify objects by detecting their naturally occurring emissions.) Some projects, such as the Space Surveillance and Tracking System (SSTS), have been downgraded because they depend on passive discrimination.

As a result of the anticipated problems with passive discrimination, SDI has now turned to the concept of interactive discrimination. This concept is designed to use low-power lasers or particle beams fired at objects in the midcourse to produce observable changes in them, whereupon passive sensors would compare the changes

Figure 14

Sandia National Laboratories

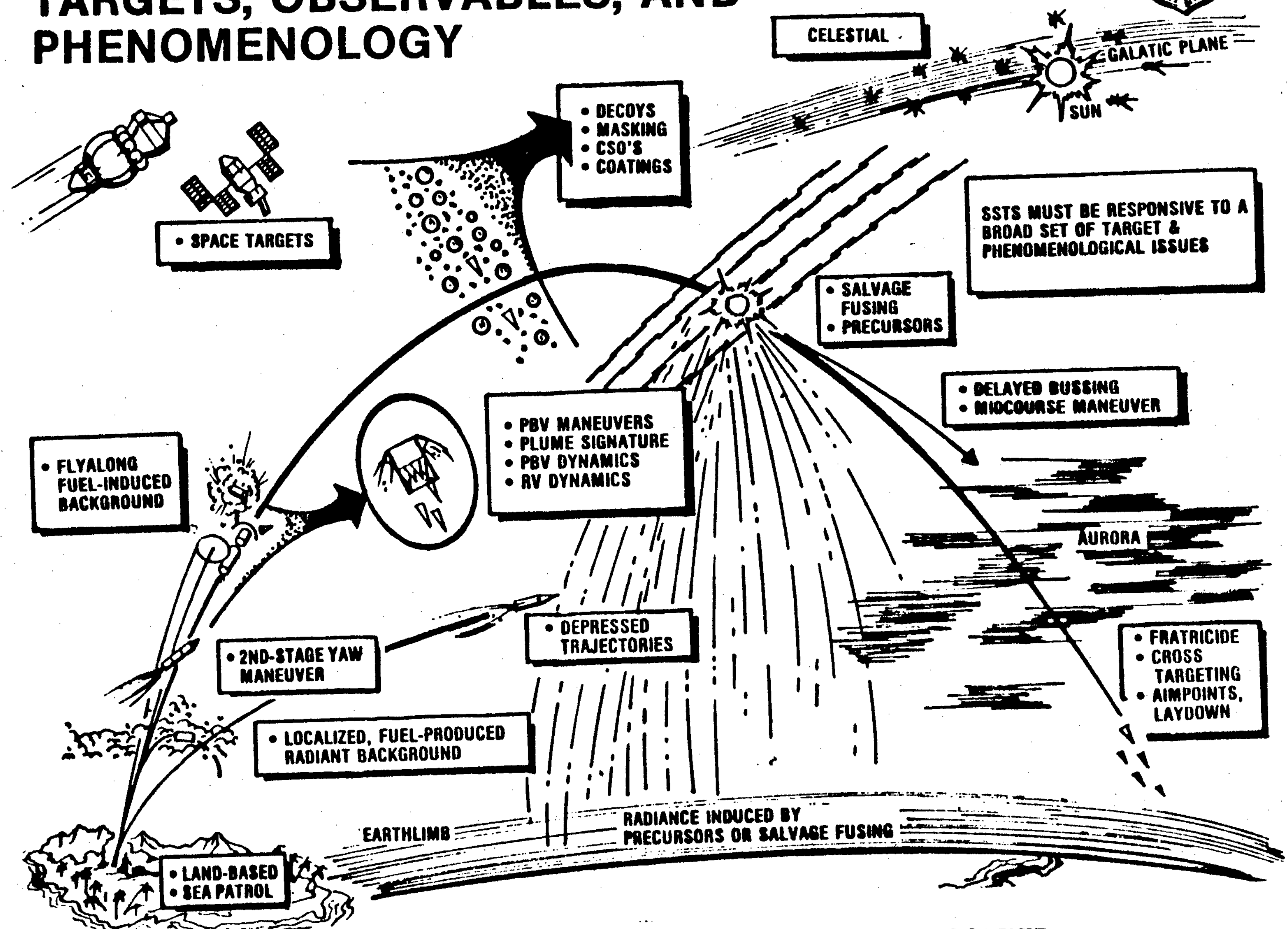
"....THEY BELIEVE THAT THERE ARE NO ABSOLUTES IN WEAPONS TECHNOLOGIES, THAT ANY WEAPON CAN NOT ONLY BE COUNTERED BUT ALSO WARPED SO THAT IT APPEARS TO BE SOMETHING IT IS NOT. IN COUNTERING RADAR, FOR EXAMPLE, THEY WOULD MUCH RATHER MAKE IT APPEAR TO BE FUNCTIONING NORMALLY BUT CAUSE IT TO YIELD INACCURATE INFORMATION THAN TO JAM IT SO THAT THE OPERATOR <u>KNOWS</u> IT IS NOT WORKING PROPERLY."

"LONG WAVE INFRARED RESEARCH IN THE SOVIET UNION"
RICHARD E. THOMAS, TEXAS A&M
MARCH 1984

Figure 15

UNCLASSIFIED

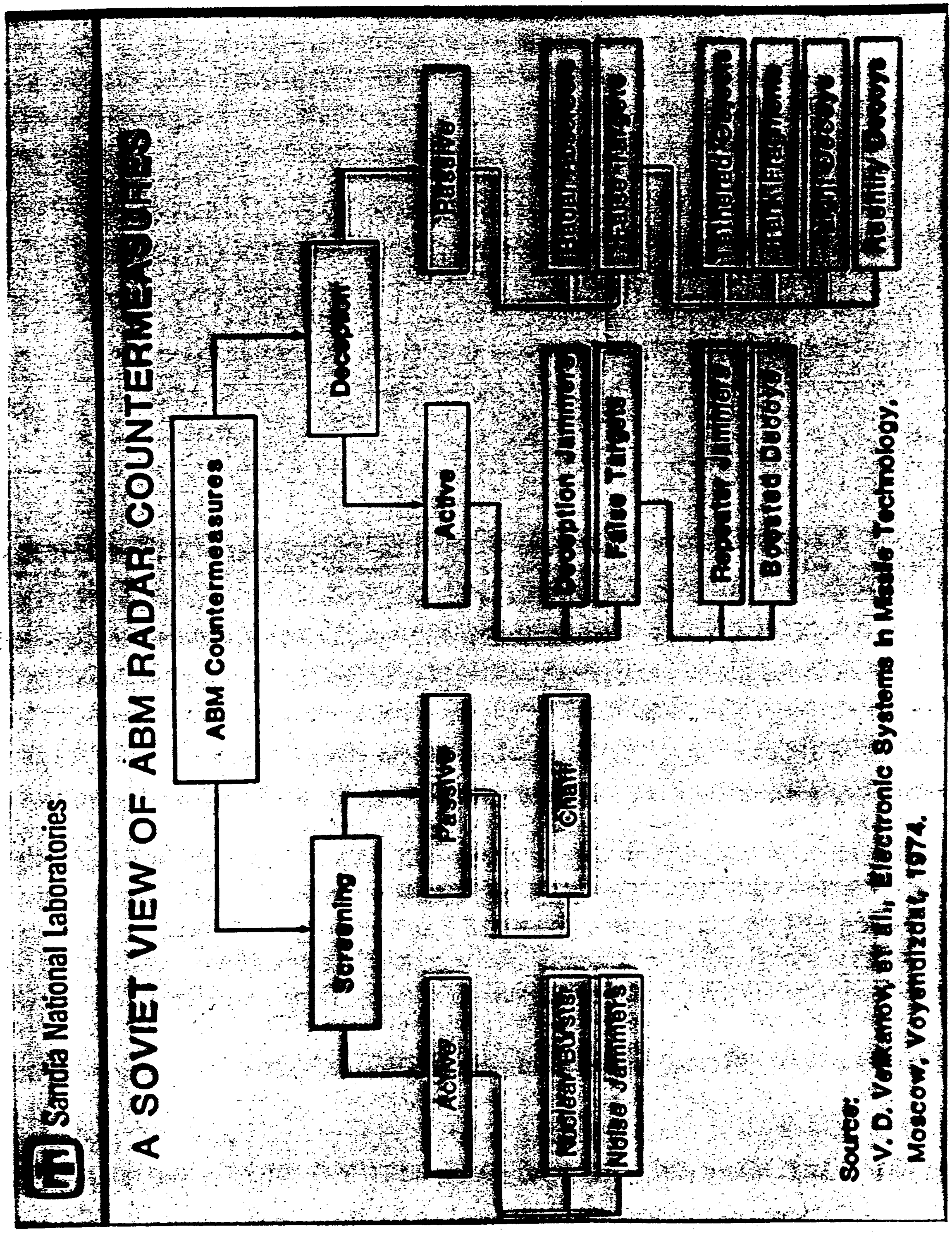
SSTS
TARGETS, OBSERVABLES, AND PHENOMENOLOGY



UNCLASSIFIED

25SSD40790
DWK

Figure 16


Sandia National Laboratories
A SOVIET VIEW OF ABM RADAR COUNTERMEASURES
ABM Countermeasures
Screening
Deception
Active
Passive
Nuclear Bursts
Noise Jammers
Chaff
Active
Passive
Deception Jammers
False Targets
Repeater Jammers
Boosted Decoys
False Targets
Source:
V. D. Velikanov, et al., Electronic Systems in Missile Technology,
Moscow, Voyenizdat, 1974.

in the different objects to sort out the warheads from the decoys.

A question remains, however, as to why some SDI projects dealing with passive sensors continue at such a high funding level if the general conclusion is that these sensors would be ineffective. For example, SDI will spend $380 million to demonstrate in early 1989 the Airborne Optical Adjunct(AOA), which uses a passive, long-wave infrared sensor to detect warheads and decoys in the late midcourse and early terminal phases. Sandia scientists report that AOA's sensor would have significant problems discriminating warheads from decoys in a nuclear environment. SDI's program manager for sensors insisted, however, that AOA would be valuable for the detection and tracking that is needed before more sophisticated discrimination is accomplished.

Whatever final discrimination technology proves useful -- keep in mind, interactive discrimination is still largely a concept rather than a reality -- it appears that an effective boost phase defense is still critical to achieving effective discrimination. It is critical that a boost phase defense thin out the number of warheads and decoys midcourse discrimination will face. Some SDI officials, therefore, have concluded that a strategic defense minus the boost phase -- that is, based only on the midcourse and terminal phases -- would likely be be overwhelmed by a highly proliferated threat cloud of Soviet warheads and decoys.

2. Survivability

With boost-phase intercept presently recognized as the linchpin for a successful defense system, SDI researchers have concluded that the ultimate problem space-based battle stations will face is survivability. Space-based directed and kinetic energy weapons systems or laser relay stations have tremendous technological and engineering hurdles to cross just to become operational in a non-military environment. But these hurdles pale compared to operating and surviving in a military environment.

Figure 17 provides a sampling of Soviet threats and countermeasures (all of which, the U.S.S.R. would have to pay a price to implement) that could affect the survivability or degrade the effectiveness of our space-based assets. They include anti-satellite (ASAT) weapons, ground-based lasers, electronic counter-measures, space mines, X-ray lasers, pellets in orbit, paramilitary operations. As one senior SDI official stated in a briefing, "We've thought of more threats (to survivability) than even our critics have come up with." For example, every Soviet warhead the bus dispenses becomes a potential ASAT weapon if it is salvaged fuzed and explodes near a space platform. Furthermore, the technology to produce an effective ASAT weapon in most instances is less stressing than the technology to produce an effective ABM weapon.

Here is a sampling of some of the more difficult problems:

a. Keep-Out Zones

Figure 17

SAMPLE OF SOVIET THREATS AND COUNTERMEASURES SDI MIGHT FACE

Anti-satellite weapons	Ground-based lasers
Electronic countermeasures	X-ray lasers
Space mines	Pellets in orbit
Para-military forces	Proliferation
Depressed trajectories	Clustering ICBM launches
Booster hardening, spinning	Fast-burn boosters
Quick PBV release	Maneuvering
Salvage fusing	Penetration aids
Decoys	Anti-simulation
Masked warheads	Saturation attack

In the past, SDI officials have talked of establishing keep-out zones to protect against ASAT's and space mines. The U.S. would declare a certain area around a satellite -- say, hundreds or thousands of kilometers -- off limits. Anything entering the keep-out zone would be destroyed. "Rules of the road" would be established in space, much like the law of the high seas, which would govern what would be threatening to U.S. assets and thus subject to attack.

Keep-out zones, however, create countless headaches for military planners and diplomats. First, the 1967 Outer Space Treaty, which declares that no nation can claim sovereignty over outer space, would have to be changed. Second, with thousands of U.S. systems in space and presumably with thousands of Soviet space-based systems in a similar strategic defense, and with each U.S. and Soviet satellite having its own keep-out zone, space will likely become too crowded with literally no room for satellites to move. Third, ambiguous behavior would greatly complicate enforcement of keep-out zones. Is an intruder a straying satellite or a threat? There would also be considerable room for deception, such as hiding space mines or nuclear devices on what are ostensibly commercial vehicles. In our briefings, we asked repeatedly how our space-based elements would be protected from Soviet space mines. We never received a plausible answer.

b. Satellite Defenses

As Figure 18 depicts, other survivability measures being considered include hardening satellites so they can withstand attack, making them maneuverable to evade attack, giving them a shootback capability, or proliferating the defense with more satellites and decoys. However, SDI studies show that all these counter-countermeasures pose severe problems.

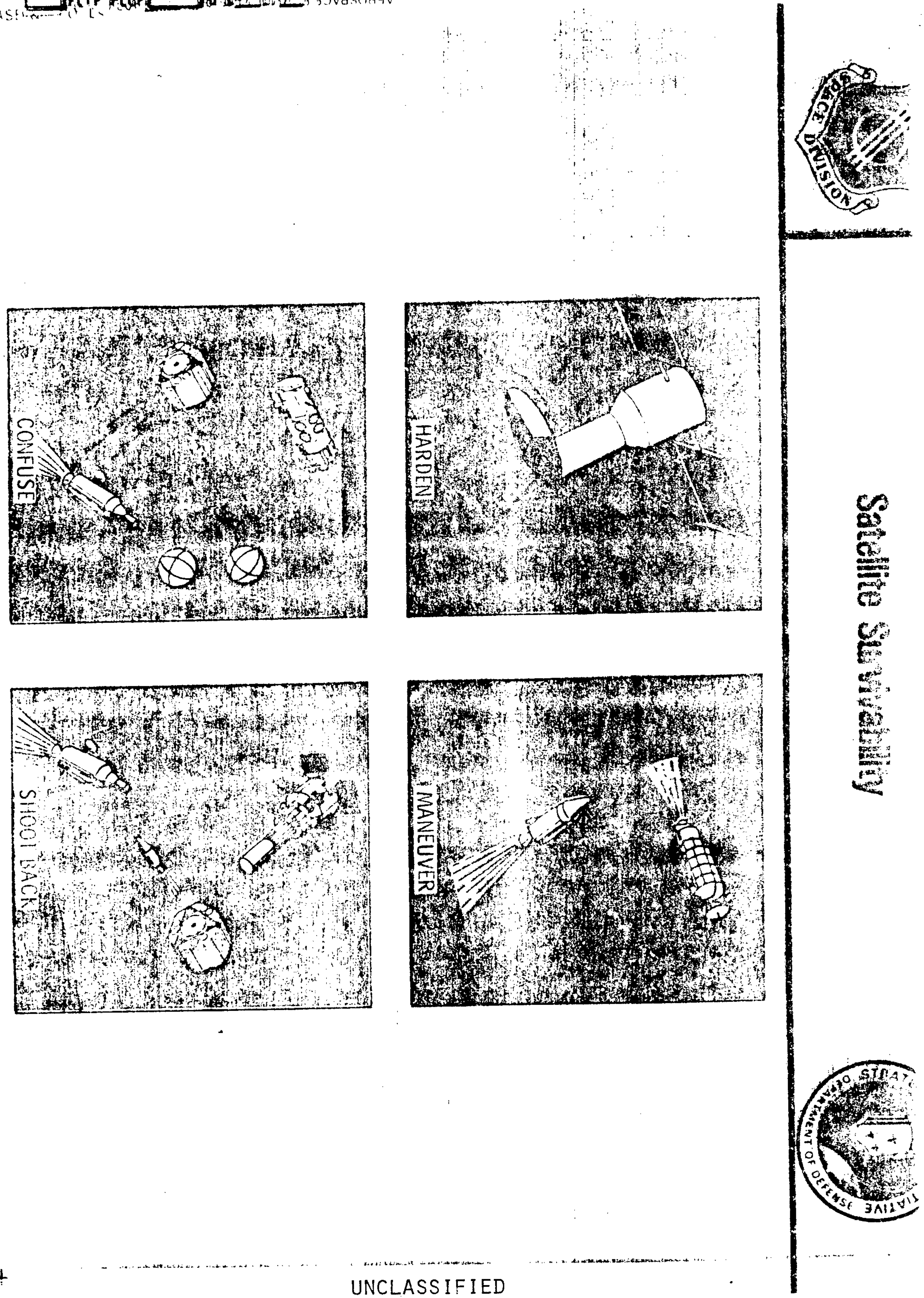
In order to harden a battle station, make it maneuverable, and give it a counter-attack capability, at a minimum its mass would have to be doubled. The U.S. would have considerable difficulty attaining the lift capacity to put this much weight up in space. The U.S. would also have difficulty proliferating satellites to any great extent because it would be too expensive, according to one senior SDI official. If the Soviet defense develops a capability to discriminate between a warhead and decoy, it will likely be capable of discriminating during an attack between defensive weapons and decoys.

No doubt, there will be other survivability measures -- preferential defense of satellites, for example -- which would not be as stressing to the defense. However, at this point survivability research is in its infancy.

c. Particle Beams And X-ray Lasers

Because it is impractical to shield against neutral particle beams in space, some SDI officials believe the most difficult survivability problem the U.S. would face is Soviet neutral particle beam weapons, which might destroy satellites despite keep out zones, or otherwise punch a hole in the defense. As one SDI official described it, a future scenario in which both the U.S. and the

Figure 18


Satellite Survivability
SPACE DIVISION
CONFUSE
HARDEN
SHOOT BACK
MANEUVER

U.S.S.R. deployed neutral partcile beam weapons in their defenses and in which these weapons had an anti-satellite capability would be something like "the re-enactment of the 'Shootout At The OK Corral.'" He who shoots first, wins.

Pop-up X-ray lasers also present an ASAT threat. Indeed, one of the biggest problems with the U.S. deploying a pop-up X-ray laser in a defense is the Soviets responding with a pop-up X-ray laser in the counter-defense (see Figure 19).

d. Attrition Attacks

The survivability of space-based assets in wartime is not the only dilemma. They may also have difficulty surviving in peacetime. For example, one nagging problem for SDI officials is peacetime attrition attacks. A few U.S. satellites occasionally could get picked off, perhaps with ground-based lasers, and the Soviets might deny any responsibility, claiming the satellites were defective.

Or, what if the Soviets, ignoring their treaty obligations, declare the space over them a keep-out zone and threaten to shoot down any U.S. BMD battle stations? Since deployment of a U.S. defense system would have to be phased, could the Soviets block a defensive system before enough of it was deployed to counter the counter-measures?

Again, this assessment of survivability problems is not exhaustive. There are many more difficulties and complications involved in deploying space-based defenses capable of withstanding attacks from the offense.

What is the current overall assessment on survivability? At this point, it appears bleak. Scientists at the Sandia Laboratory who have been intensely studying this question have come to the conclusion that space-based, boost-phase defenses can <u>never</u> be made survivable, unless by treaty. Boost-phase defenses will never be survivable unless the U.S. and U.S.S.R. agree to certain rules of the road and deployment restrictions through arms control.

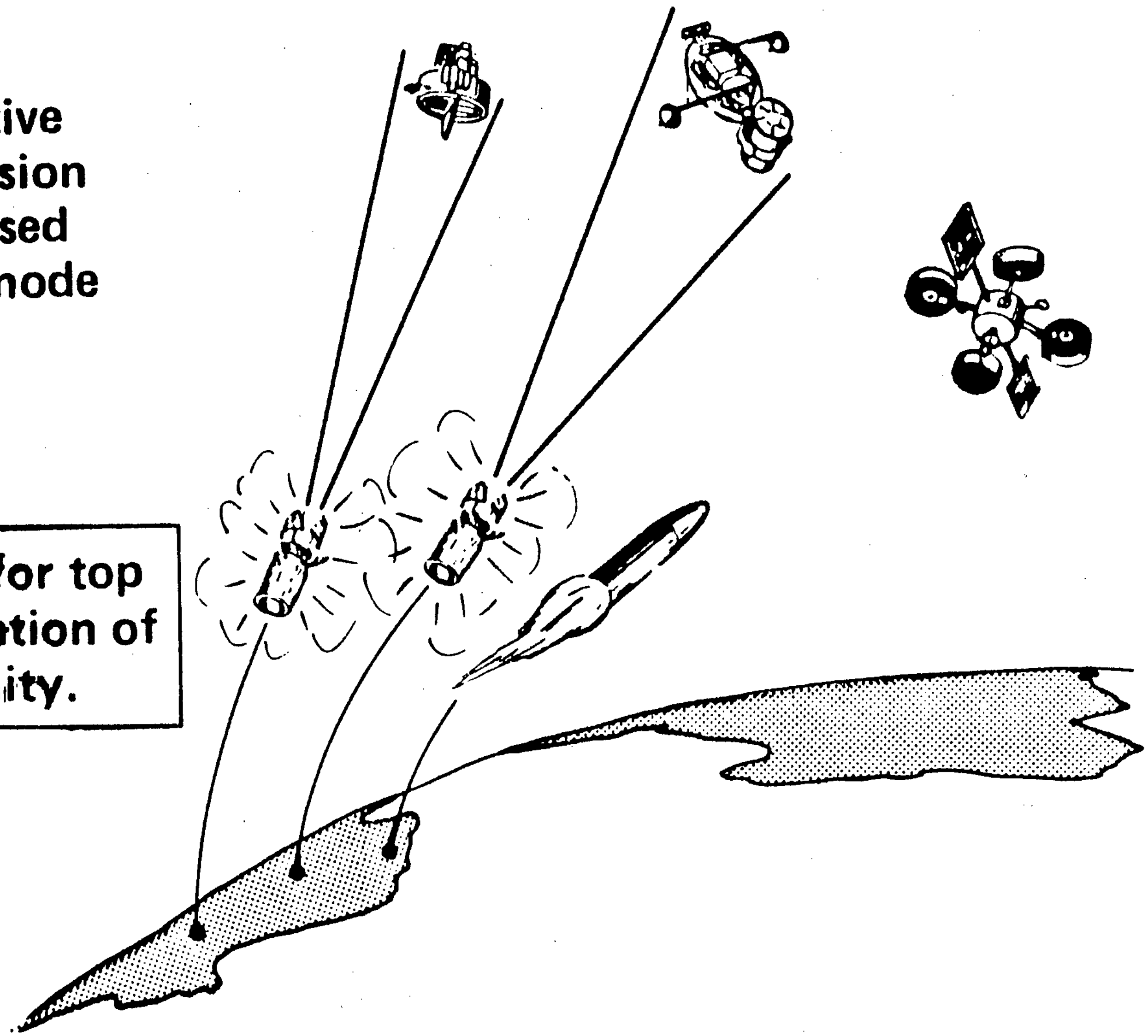
However, in the same breath, these scientists point out that it is wishful thinking (or a myth, as Figure 20 states) to believe that survivability can be legislated through arms control. As one SDI scientist said, if the space-based system "doesn't work on its own, it won't work with arms control."

Furthermore, if space-based defenses are not survivable with or without arms control, it does not leave too many appealing options for boost-phase defense. For example, one Sandia scientist has proposed solving the survivability problem by deploying U.S.-Soviet space battle stations that would be built <u>jointly</u> by both superpowers and by prearrangement would shoot down ASATs or missiles launched by either side. The scheme, which has been dubbed MIMAS for Mutually Implemented Mutually Assured Survival, may be an elegant technological

Figure 19

Counter-defense role

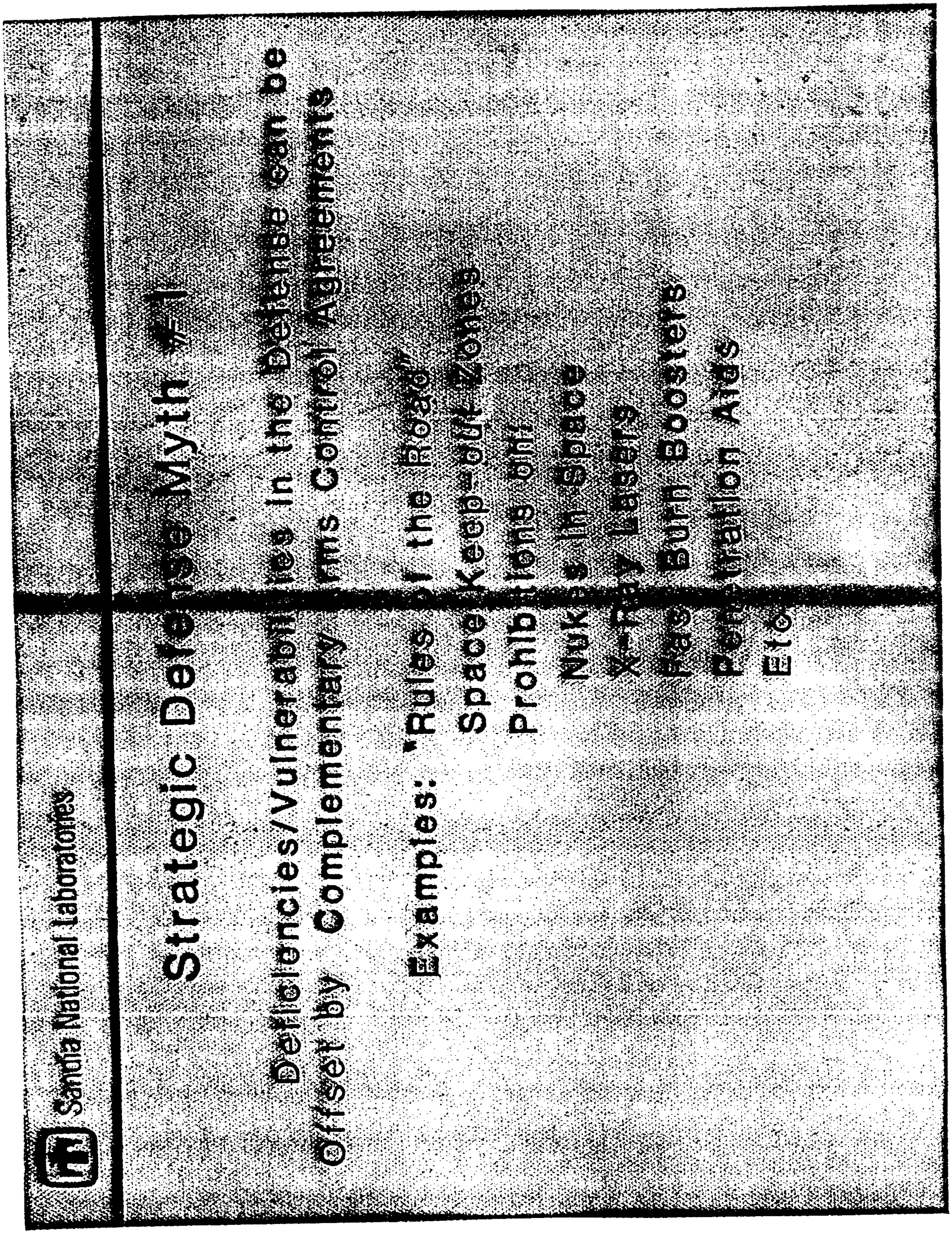
An x-ray laser can be an effective defense suppression weapon when used in the pop-up mode



The DTS called for top priority investigation of technical feasibility.

MKU-XRL-8511-144

Figure 20


Sandia National Laboratories
Strategic Defense Myth #1
Deficiencies/Vulnerabilities in the Defense can be Offset by Complementary Arms Control Agreements
Examples: "Rules of the Road"
Space Keep-out Zones
Prohibitions on:
Nukes in Space
X-Ray Lasers
Fast Burn Boosters
Penetration Aids
Etc.

solution to the survivability problem. But at this point, it is difficult to imagine any type arms control or other defense regime that might permit this kind of operation.

Not surprisingly, SDI's program and project managers who supervise space-based weapons activities are optimistic that the survivability question may be overcome. Some admit, however, that solutions to certain aspects of the survivability dilemma (for example, protecting transition-phase deployment) will have to be legislated through arms control.

Nevertheless, the Sandia Laboratory findings pose grave questions for the direction and possibilities of current SDI research. Billions of research dollars are being pumped into space-based weapons systems. The Sandia findings suggest that this money might well be wasted. Furthermore, if boost-phase defense is as critical to the success of the entire system as SDIO's leadership presently thinks it is, serious questions need to be asked -- and asked early -- as to whether a comprehensive strategic defense is really feasible.

It is also obvious from this discussion that one area requiring much more detailed analysis is the threat strategic defenses would face. The analysis should be made not just of the threat projected for today or in the next decade, but also the generated threat into the 21st century when a strategic defense might be deployed. It was clear from our briefings that neither the Air Force, the Army, nor the national laboratories were using the same threat assessment. In fact, one Air Force officer referred derisively to the many different assessments as the "threat of the month club." Such comments, however, can be expected as long as the SDIO has not placed realistic parameters on the nature and extent of the threat a strategic defense would be required to deter.

B. Direction Of The Program

The second major emerging problem concerns the direction the SDI program is taking. This direction, which impacts heavily on the management of the research effort, has many aspects that can be categorized as follows:

1. Shifting Priorities

As noted above, the current SDI program is substantially different from the one proposed by the Fletcher Panel or projected in the FY84 and FY85 budget submissions. By some counts, almost one half of SDI's projects have been downselected, reoriented, or given new missions. Perhaps no better example can be found of the change than in the Directed Energy Weapons Program.

At the beginning of 1985, SDI officials proposed to spend more than $1 billion in the next three years researching space-based chemical lasers in order to conduct a major demonstration project in the early 1990's. Critics at the time questioned the advisability of pumping so much money into the research and an early demonstration project considering the significant operational problems space-based chemical lasers would have surviving and then attacking missiles in the boost phase. Nevertheless, SDI insisted that such lasers would be a valuable weapon for boost-phase attack and a accelerated program to demonstrate them was justified.

Today, the space-based chemical laser project has fallen from favor. Its FY86 budget has been cut in half from the $348 million that was requested at the beginning of last year. It appears obvious, however, that Congressional budget cuts were not responsible for the shift in emphasis away from the project. SDI officials have come to realize that what the critics were saying was correct: there was too much evidence indicating that space-based chemical laser weapons had serious operational limitations that would make them militarily ineffective. (However, the Alpha experiment to demonstrate a low-power chemical laser is still being funded generally at the same level requested last year. SDI officials insist that the project still has value as a test bed; however, clearly another reason for its continued high funding is that execution of the Alpha contract is too far along to terminate economically.)

Other directed energy weapons projects have had their missions changed. Last year neutral particle beam (NPB) technology was being actively pursued as a space-based weapon. SDI officials now realize neutral particle beams would have severe operational hurdles to cross as a BMD weapon in the near term, so a lower-powered version is being pursued for interactive discrimination. The same verdict is being given for X-ray lasers, whose only near-term mission would be midcourse discrimination. Figure 21 depicts the new roles for directed energy projects in the near term. Last year, most of the emphasis in the Directed Energy Weapons Program was on developing directed energy <u>weapons</u>. This emphasis has changed. Directed energy technology for interactive discrimination has been elevated to equal emphasis with directed energy weapons research.

The directed energy technology that seems to have jumped to the head of the line as a boost-phase weapon is the free electron laser (FEL), particularly the Induction Linac Free-Electron Laser at Livermore Laboratory (see Figure 22). The Induction Linac FEL, which would be ground based, has advantages over other FELs in terms of efficiency and power scalability. As attractive as the Induction Linac FEL might be, SDI officials still warn, however, that it faces major technological hurdles in building the laser, propagating a sufficiently lethal beam through the atmosphere, and constructing the relay mirrors.

The SDIO should be commended for recognizing problems in certain technologies and in shifting its priorities. Indeed, by its very nature, a research and technology development program is supposed to be constantly changing. Furthermore, the SDIO should exercise a certain degree of management freedom and flexibility to respond to technological evolution and delays in technological advances. But the dramatic changes that have come about in SDIO's program in the past year pose a unique set of problems for Congress.

Figure 21

NEW APPLICATIONS FOR DIRECTED ENERGY WEAPONS

Technology	Basing Mode	Application Near Term	 Far Term
Free electron laser	Ground- or space-based	Midcourse discrimination	Boost phase, post-boost phase, midcourse discrimination
Neutral particle beam	Space-based	Midcourse discrimination	Midcourse discrimination
HF chemical laser	Space-based	Midcourse discrimination	Boost phase, post-boost phase, midcourse discrimination
RP excimer laser	Ground-based	Midcourse discrimination	Boost phase, post-boost phase, midcourse discrimination
X-ray laser	Pop-up	Midcourse discrimination	Midcourse discrimination, boost phase

Source: Unclassified SDI briefing chart.

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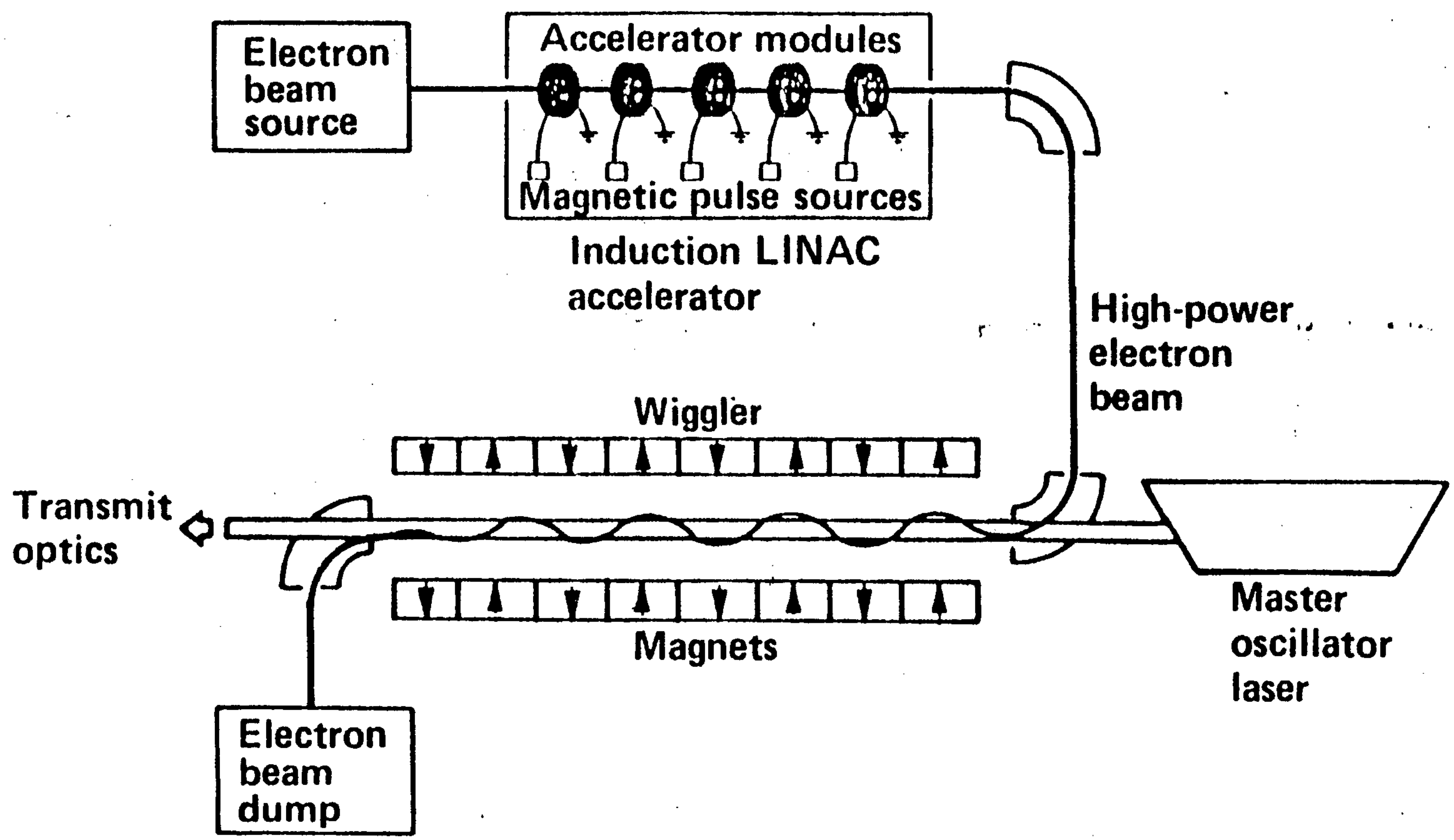
Figure 22

Induction LINAC FEL



- High current
- Single pass extraction
- High output power density

MAC-DFW-8504

In many ways, SDI is not like any research project the United States has ever undertaken. As noted before, it is intensive, heavily funded, schedule-driven research being conducted not just to explore technology but to decide by the early 1990s what systems are feasible for development and deployment. Priority status for a particular project means hundreds of millions, even billions, of dollars worth of funding. For example, one midcourse discrimination experiment now a high priority because it will test a neutral particle beam accelerator in space may cost up to $1 billion alone. Several one-time experiments will cost hundreds of millions of dollars each, according to SDIO.

Last year Congress was asked to appropriate hundreds of millions of dollars for priority projects, many of which are no longer priorities this year. This year, Congress is being asked to appropriate hundreds of millions of dollars for a different set of priorities. Congress should be concerned about these changes for two reasons.

First, the dramatic shifts in priorities clearly indicate that SDI research, contrary to public pronouncements, is still at a very early stage. In reality, SDI officials, despite the tripling of their budget, have revealed relatively little about what technologies will or will not result in a feasible, affordable and survivable comprehensive missile defense. At this point, they are making only educated guesses at what that defensive system might look like.

Congress, therefore, should evaluate carefully the SDI priorities and the hundreds of millions of dollars worth of funding they entail. Moreover, a certain degree of skepticism is warranted over claims that certain projects have tremendous potential and deserve priority funding.

Second, the SDI priorities Congress is being asked to fund this year may change again next year. As one SDI official pointed out, "there are opportunities for major technological breakthroughs for any of the projects we've down-selected." A technology presently not considered as militarily useful may well move to the head of the line in the future. Indeed, the fact that the priorities were shifted this past year in part as a result of the Phase I systems architecture studies may well result in another shift in priorities next year.

SDI's Panel on Computing in Support of Battle Management, appointed to consider the computing requirements for strategic defense, concluded in its 1985 Eastport Study that the Phase I architectures incorrectly "treated the battle management computing resources and software as part of a system that could be easily and hastily added." The architectures, the study continued, were developed "around the sensors and weapons and have paid only 'lip service' to the structure of the software that must control and coordinate the entire system."

The architectures should have been driven more by the requirements of battle management, according to the Eastport Study. As a result of this study's recommendations, which called for a strategic defense system "less dependent on tight coordination," some of the weapons and sensors given high priority in the Phase I architectures may well be down-graded. In other words, the Eastport Study conclusions indicate that the architecture studies may well have to be redone to account for the special requirements of battle management computing.

So far, it has been easy for the SDIO to shift resources to accommodate these changes. But as the total funding level increases, as contracts mature, and as hardware is produced, it will not be as easy to shift funding to new priorities (as we may have discovered with the Alpha project). In other words, the days of easily making up for premature priorities are nearing an end.

Furthermore, by rushing toward early technology demonstration projects SDI officials may well end up with a number of premature choices and Congress may well end up wasting a lot of tax dollars. Congress, therefore, should consider the merits of an SDI program oriented more toward basic and applied research, which is conducted at a more measured pace and which isn't forced to prematurely establish priorities.

2. Schedule-Driven Research

As noted in the first part of this report, the SDI organization has decided to stick with the same decision timeline established with the technology-limited budget it first proposed, even though Congress has allowed for a more funding-limited budget. As a result, SDI officials freely admit that there will be more risks associated with the early 1990's development decision than if they received the full appropriations they requested.

Since there is little chance that Congress will make up for past funding cuts or appropriate all that SDI has requested for FY87 and the next several years, a closer look must be given to the risks entailed by sticking to an early 1990's decision date. The following are some of the problems created by the 1990's decision deadline:

- Because of funding cutbacks and the discovery in some cases that the technological hurdles are greater than first thought, many critical technologies won't be on line for a development decision by the early 1990's. For example, because of the inadequacies of passive discrimination and the relative newness of interactive technologies, SDI may not be prepared for a development decision of any value for midcourse discrimination by the early 1990's. Too many milestones have either been pushed back or appear unrealistic at this point. It is therefore likely that a development decision in the early 1990's would be made not only with significant risks, but also with significant gaps of information.

- Because an early 1990's development decision would be based on incomplete research, the chances are greater that bad choices will be made in that decision. At the very least, SDIO will be commiting itself to technologies which are in hand or more mature (such as space-based kinetic kill vehicles) but which have limited growth potential (e.g., against Soviet fast-burn boosters).

Moreover, a chief researcher at Livermore laboratory expressed concern that schedule-driven research might result in a "series of sleazy stunts" rather than well thought-out experiments. As he pointed out, the objective of research is not succcess but increased knowledge. The pressure to achieve success will ultimately result in a degradation of the research.

The Eastport Study also expressed concern that a "time-driven choice for a specific strategic defense architecture" might lock SDI into a defense that future computers and software would not be able to manage. While shifting priorities might be a relatively painless task at the moment, early 1990's development decisions will be more difficult and expensive to change later.

- The development decision for technologies still projected to come on line by the early 1990's may be more complex and subjective than some realize. Take, for example, space-based kinetic energy weapons, SDI's only near-term deployment option at the moment for boost-phase kill. By the early 1990's, this project will only be capable of completing "near-term validation experiments," according to the Kinetic Energy Weapons (KEW) Program manager, instead of a single demonstration of the technology.

These validation experiments will consist of a host of subtests, which, when taken together, will supposedly demonstrate the feasibility of space-based KEWs. Decisionmakers in the early 1990s thus will be shown different experiments or their parts, simulations and modeling where experiments could not be conducted, and "different pieces of information," according to the program manager, and from all this a "straightforward decision to go into full-scale development will be made." The program manager conceded that subjectivity will be a factor in the decision. "There will likely be disagreement on whether we go forward," he said. "In that decision there will be a level of risk and a level of certainty."

Decisions on other technologies will likely be even more subjective. For example, "if one wants to decide which software development technique is most appropriate for a particular set of the battle management software," reports the Eastport Study, "one can not make an objective assessment; it will likely rely at least partially on anecdotal evidence and the subjective judgement of experienced people."

For that matter, more discussion is needed as to what exactly an early 1990's development decision will produce. Will it be a go or no-go decision on a baseline architecture with X number of phases and Y weapons that will take Z years to deploy? Or will it be a go or no-go decision on the general evolution of strategic defense with no precise projection of its parameters or capabilities?

- There is a danger that schedule-driven research will force technological development to be ramped down in order to achieve technology demonstrations for the early 1990's decision date. In this case, decisionmakers would have their demonstration, but it would be at a lower technological level than if the demonstration deadline were extended until more sophisticated and higher value technology came on line.

There is already evidence that this ramping down of technology for demonstration projects is occurring in SDI. In order to avoid part of a $103 million cost overrun on AOA, the Airborne Optical Adjunct (and no doubt its political fallout since the overrun surfaced just 8 months after the contract was awarded to Boeing Co.), SDI cancelled a $62 million subcontract with Aerojet Electrosystems Co., which was to provide an advanced sensor for one of the two AOA planes to be demonstrated. The AOA plane would be deployed to track warheads in the late midcourse and early terminal phases of the defense.

Setting aside for the moment the serious question of whether the contractor "bought into" the contract (which we were assured by SDI officials was the case) and whether the Army knew it was a buy-in (which we were told was not the case), SDI's handling of the cost overrun is disturbing for the following reason.

Aerojet was to develop a state-of-the-art sensor, which was to be more advanced than the other sensor another subcontractor, Hughes Electro-optical and Data Systems Group, was to build using off-the-shelf technology. The Aerojet sensor was to have a significantly different detection capability than the Hughes sensor. It was to be more sensitive, have a longer acquisition range and be more resistant to nuclear effects than the Hughes sensor.

In order to avoid a cost overrun and meet generally the same demonstration deadline, SDI dropped the Aerojet contract and will likely be demonstrating a less capable Hughes sensor on AOA. Not only that, but SDI has also forfeited the technology base Aeroject would have established with development of its sensor. In addition, it has lost the advantage of two types of sensor approaches, and has left itself in a risky position if the one AOA plane with the Hughes sensor experiences a catastrophic failure.

As mentioned earlier in this report, we question the overall value of AOA because of the limitations of passive discrimination. SDIO officials insist, however, that AOA is needed as a supplement to more sophisticated discrimination. If there is a supplemental role for AOA and considering the severe technological hurdles AOA still must cross, particularly in a nuclear environment, the question then arises as to whether the Aerojet contract should have been dropped and whether the demonstration deadline should not have been left open-ended for the moment. As it now stands, decisionmakers will get the demonstration, but it will be of a less capable system.

There is nothing unusual about military research programs having definable objectives and schedules for meeting them. There is also nothing disturbing about program managers striving to meet those goals within a set schedule. The problem arises when the objectives are unrealistic and the deadlines are arbitrary. Congress, therefore, should ask two very important questions about the schedule-driven research SDI is pursuing:

First, what is the justification for an early 1990's development decision? Why is it so important to stick to that deadline if it will entail such risks? The authors of this report were offered no substantive justification for the early 1990's decision date. Certainly the Soviet ABM program was never cited as a reason. At this point, it appears to be an arbitrary date.

Second, what kind of tradeoff is there between adhering to an early 1990's development decision date and extending the deadline to allow for more maturation of the research and to continue a vigorous research effort across a wide spectrum of technologies? It is clear from the above discussion that an early 1990's decision carries adverse consequences. These must be weighed against the consequences of delaying that decision.

3. Transportation, Support and Logistics

In considering the cost and complexity of a comprehensive strategic defense both SDI proponents and opponents tend to focus on just the weapons, sensors and battle management components that would be deployed. Indeed, these systems are daunting by themselves. The Phase I architecture studies envision hundreds of space-based platforms for the surveillance, tracking and acquisition of ICBMs and their warheads, thousands of space-based kinetic kill vehicle battle stations, a multitude of relay mirrors in space, battle management and C^3 satellites in geosynchronous orbit, hundreds of land-based radars and battle management centers, and tens of thousands of ground-based interceptor rockets.

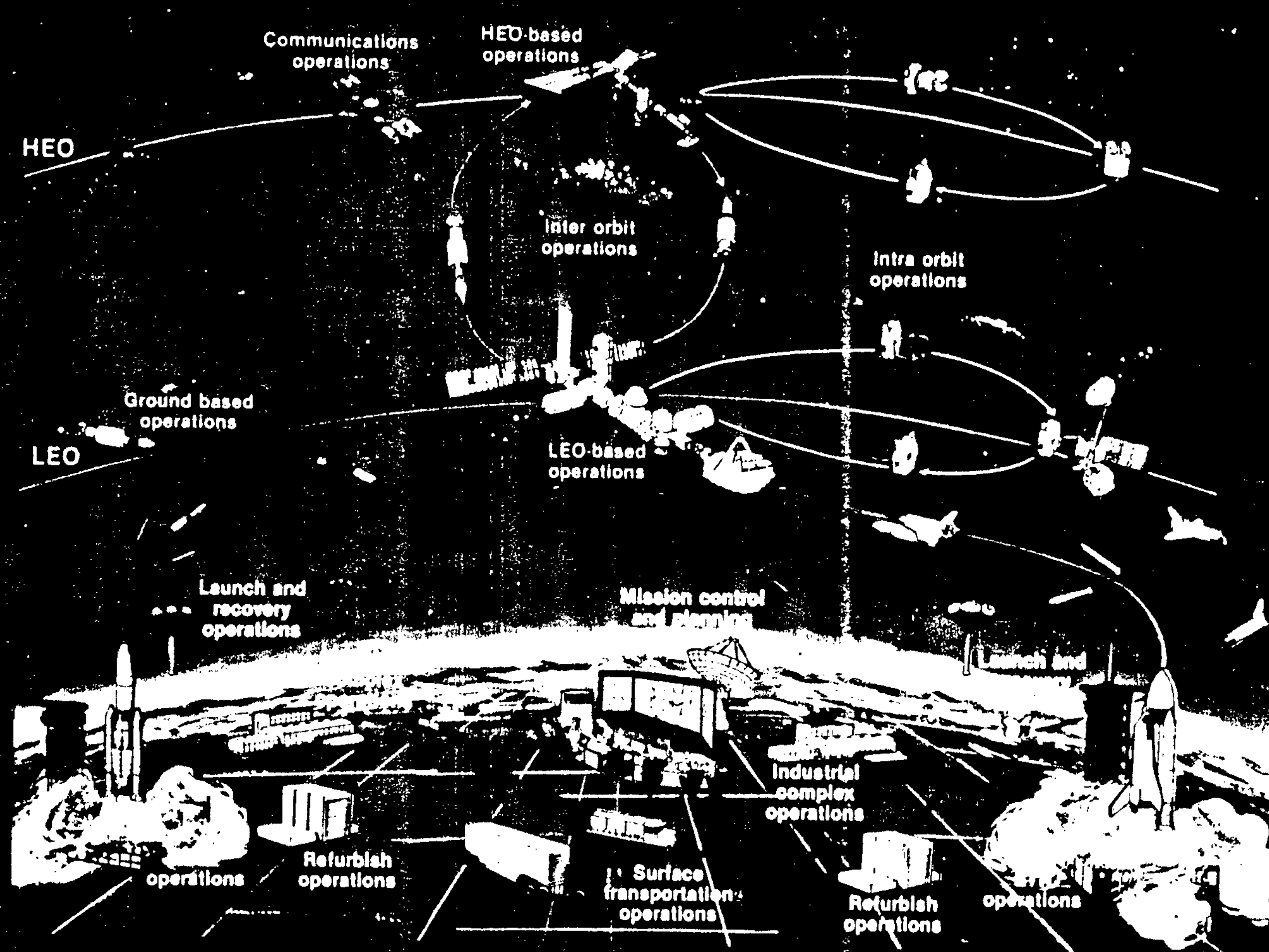
Too often ignored in considerations of a strategic defense, however, is what will be needed to put the defense in place and maintain it. To get a true picture of the cost and complexity of strategic defense one must superimpose over the architecture of weapons, sensors and computers the architecture of transportation, support and logistics.

Figure 23 depicts the minimal architecture that might be needed to deploy and maintain a strategic defense. It includes massive launch and recovery operations, an industrial complex to build the weapons and sensors, refurbish operations for maintenance and conversions, mission control and planning operations, low-earth orbit and high-earth orbit operations to deploy and maintain space-based assets, inter-orbit operations and intra-orbit operations, communications operations to establish and maintain the nets, plus an extensive ground transportation system.

It appears that the transportation-support-logistics system for a comprehensive strategic defense may well be as complex and unprecedented as the defense itself. So far, the debate over SDI has centered on whether the defense is feasible. However, serious

Figure 23

TRANSPORTATION, SUPPORT AND LOGISTICS SYSTEMS INTEGRATION



questions should now be raised as to whether a transportation-support-logistics system for the defense is feasible.

The U.S. transportation-support-logistics system is currently inadequate and would entail too much cost to sustain a strategic defense, SDI officials concede. That is why General Abrahamson and other SDI officials are hesitant to forecast SDI deployment costs based on current U.S. transportation-support-logistics capabilities. They prefer to forecast what strategic defense deployment should cost.

In order to make SDI affordable in the future, and as a result cost-effective at the margin per one of Ambassador Nitze's criterion, there will have to be substantial change in U.S. transportation-support-logistic capabilities. And for this change to occur, SDI officials admit, there will have to be a revolution in the research, development, testing and production methods of the Defense Department and the U.S. defense industry. What follows are but a few of the changes that must occur:

a. Henry Ford Production Techniques

Presently each U.S. satellite is individually handcrafted. No two are exactly alike. More uniformity and efficiency is achieved with ground-based missiles and launchers, but not a great deal. Space shuttles cost about $2 billion each, MX missiles presently about $67 million each.

In order to make the tens of thousands of SDI missiles and satellites affordable, SDI officials say that "Henry Ford production methods" will have to be introduced into the way these vehicles are produced. The aerospace and defense industry will have to undergo fundamental changes in their methods of production so a missile will cost hundreds of thousands of dollars instead of millions, and a satellite will cost millions of dollars instead of hundreds of millions.

b. Transportation Requirements

SDI's rough schedule, according to its program managers, calls for a development decision by the early 1990's as noted above, deployment beginning in the late 1990's, with useful service of the defense system not commencing until about 2005. In other words, the more than $5 billion the President is requesting in FY1987 for SDI research is for a system that will not be in service until nearly two decades later.

This lengthy germination period for SDI seems to stem in part from the transportation capability that would have to be developed to place space-based defenses in orbit.

Presently, it costs $1,500 to $3,000 to lift a pound of material into orbit. U.S. space shuttles and other launchers now put less than one million pounds in space per year. The Phase I architecture studies predicted that anywhere from 20 to 200 million pounds of SDI

Figure 24

THE CHALLENGE

- 27 CANDIDATE ARCHITECTURES
  - —20,000,000 TO 200,000,000 LB TO ORBIT
- IN PERSPECTIVE
  - —600 TO MORE THAN 5,000 SPACE SHUTTLE LAUNCHES
- REPRESENTATIVE ARCHITECTURES DEVELOPED
  - —REPRESENTATIVE AT ARCHITECTURE LEVEL
  - —REALISTIC AT SYSTEM LEVEL
  - —BASELINE: 58,000,000 LB OVER 23–YEAR PERIOD

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Figure 25

CURRENT COSTS

- SPACE SHUTTLE
  - —$100 TO $180 MILLION PER LAUNCH
  - —$100 MILLION PER UPPER STAGE
- COMPLEMENTARY EXPENDABLE LAUNCH VEHICLE
  - —$200 TO $250 MILLION
- $1,500 TO $3,000/POUND
  $87 TO $174 BILLION TO LAUNCH BASELINE ARCHITECTURE

0477 8

material would have to be put in space. That would conceivably mean 600 to 5,000 shuttle flights whose launch cost could run anywhere from $30 billion to $600 billion at today's prices. SDI officials say the cost per pound would have to be reduced to $200 to $400. (See Figures 24 and 25 for the range of architecture lift requirements. The baseline architecture calls for lifting 58 million pounds into orbit at a cost today of $87 billion to $174 billion for transportation alone).

Furthermore, the current space shuttle is too small for the SDI task. Dr. William Lucas, director of NASA's Marshall Space Flight Center has noted that 166 of the proposed SDIO payloads would not fit into shuttle craft's bay.

Even before the loss of the Challenger, the shuttle was considered inadequate to the task of SDI deployment, according to Congressional testimony last year by General Abrahamson.

Last summer, Edward C. Aldridge, Undersecretary of the Air Force, testified that NASA and DoD's projected payloads through the 1990's would require 19-24 space shuttle missions per year. This assumed, however, four orbiters achieving 24 flights per year, no major problems with the shuttle, no commercial and foreign payloads in addition to NASA's payloads, no support for the Reagan-initiated space station, and no SDI deployments. A NASA official also testified that three space shuttle orbiters could sustain only 15-20 flights per year. Clearly, the loss of the Challenger, which leaves us with only three orbiters, presents a problem if the U.S. is to carry through with the Administration's space station initiative, develop SDI, maintain a vigorous military space program, and promote the commercialization of space.

It appears evident that other space transportation options will have to be developed. The White House has directed that a study be made of those options for 1995 and beyond.

To accomplish the launching of SDI space-based elements, a variety of heavy lift rockets and a hypersonic plane are under consideration.

Timelines for heavy lift rockets indicate that Shuttle II, the follow-on to the current shuttle, would not be operational, however, until after the year 2000. A single-stage-to-orbit vehicle also would not be operational until about the year 2000. A derivative of the space shuttle that could launch material into space somewhat cheaper than the current shuttle, although probably not cheap enough for SDIO's requirements, would not be operational until about 1995 (see figure 26).

The hypersonic plane under consideration has been variously called the National Aerospace Plane, the "X-plane," the trans-atmospheric vehicle (TAV), and, by President Reagan, the "Orient Express." Such a craft would be a revolutionary airbreathing airplane with engines capable of propelling it to 4,000 to 8,000 miles per hour in the upper atmosphere, then literally accelerating itself to

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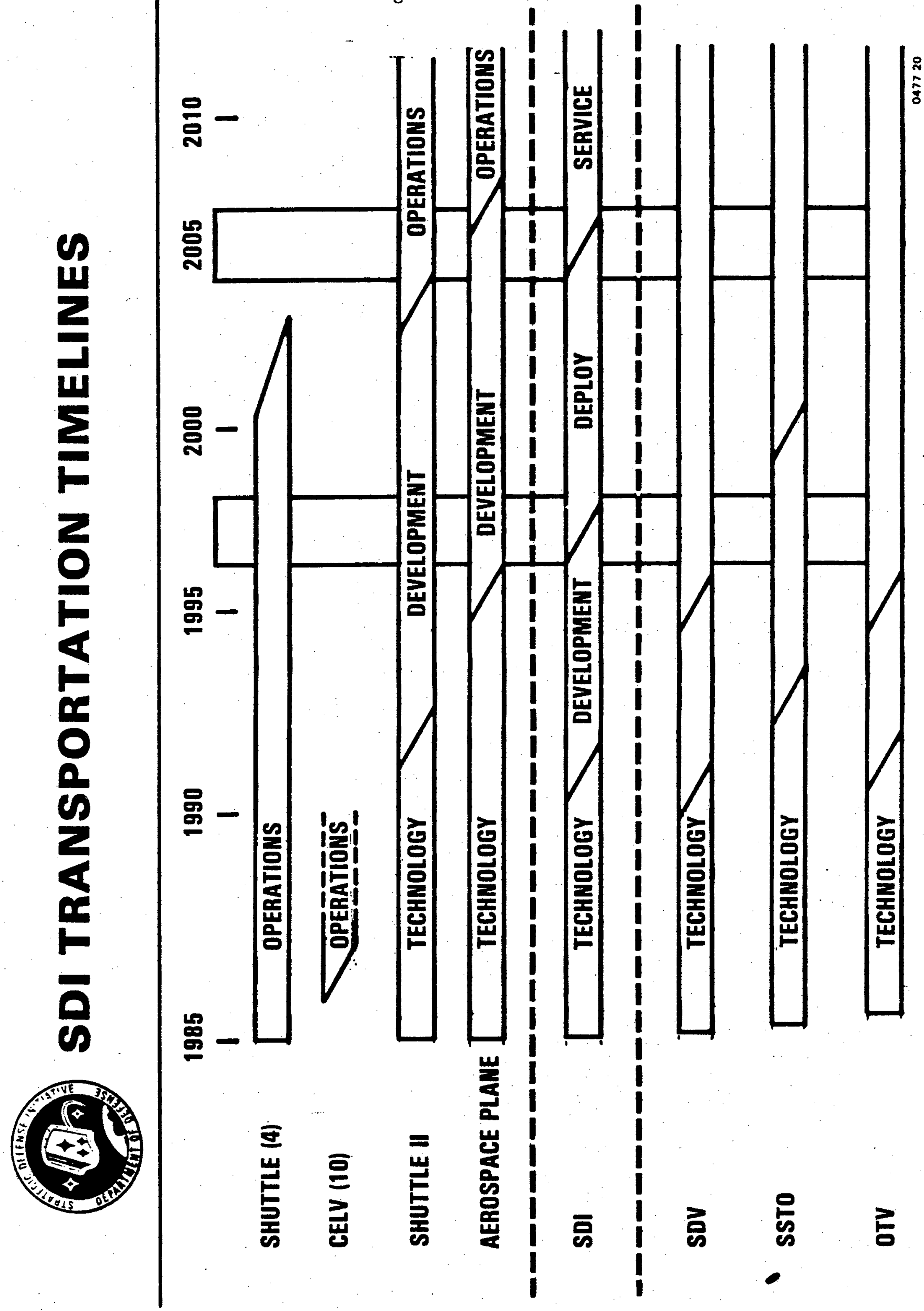
Figure 26



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sufficient speed to leave the atmosphere to achieve orbit in space.

While George Keyworth, former White House Science Advisor, has claimed that the trans-atmospheric vehicle (TAV) could be available by the year 2000, NASA Associate Administrator Raymond Calladay called it "the most complex vehicle ever built" and SDIO's briefing chart did not envision it becoming operational until the year 2005 — or about the time SDI presumably would have been deployed. While some see the TAV as a candidate launch vehicle for the strategic defense system, an SDI program manager briefing us was highly skeptical of its potential as far as SDI was concerned, noting that for the moment the TAV has "more hype than possibility."

Keep in mind that even if a launch system is available for SDI at an affordable price, there would still have to be a tremendous effort undertaken to get the space-based assets in orbit. SDI timeline charts estimate that it would take as much as eight years to physically deploy the space defense system.

Setting aside for the moment the issue of which follow-on to the shuttle will be chosen, a critical question remains. What will it take to triple the current U.S. lift capacity and cut its cost almost tenfold in order to affordably place SDI in space?

"You would need a complete revolution in the way NASA operates," said one senior SDI official. "This is a national issue, not an SDI issue. The investment by this country into the cost effectiveness of launching vehicles in space has been essentially zero since the early '70s." To radically increase its launches and decrease its costs, NASA will "have to get rid of the manpower-intensive launch operation it now has," this official explained. Currently, 26,700 persons are engaged in space shuttle support. "We're going to have to get man out of the loop," he said, adding that he did not have a firm opinion as to whether manned spaceflight will be required.

c. Support Activities

A number of auxiliary activities in support of SDI will have to undergo fundamental changes from their current capabilities. For example, the Fletcher Panel implied that SDI's communication network would be based on the defense system's own assets. The Eastport Study believes, however, that a separate network of communications satellites is needed to support the defense. But that will necessitate change. "The existing communications technology can not support the special requirements of the envisioned strategic defense system," the Eastport Study concluded, adding that existing communications security systems also "are not suitable for strategic defense."

d. Hurdles For Innovation

Of particular concern to the Eastport Study was the fact that many technology innovations never survive Pentagon bureacracy. As a result, defense technology often lags behind state-of-the-art technology. SDI will have to break this pattern so research can be conducted into innovative technologies and can produce substantially more affordable weapons systems.

As the Eastport Study noted: "it will be necessary to propagate a different culture of system development that will exploit the emerging technologies... The endless demands of project schedules, the lack of capable staff, the lack of capital equipment, the 'not-invented-here' syndrome, the conservatism in procurement decisions, and bureacracy have created a culture that resists change and takes only naive risks. SDIO must create a new culture that can adapt to changes more effectively." In other words, SDI cannot become just another weapons program fraught with delays, cost overruns and bureaucratic inertia. To be affordable it must break that mold.

Can the Department of Defense and the U.S. defense industry undergo this revolution to attain the production efficiencies needed to make SDI affordable? Can a more economical system be devised to deploy and maintain a strategic defense system? Can military research, development and procurement practices be changed to produce complex weapons systems less expensive than ever before imagined? Can the space industry be catapulted into a more efficient and vastly expanded form of operation? Can decades of entrenched administrative behavior in the Pentagon, aerospace and defense industries, and NASA be radically altered?

SDI officials remain remarkably sanguine about the revolution that must occur. They believe there can be change, particularly as a new generation of researchers, engineers and military leaders are inculcated with the new demands and requirements of strategic defense. For the moment, their attention is focused more on the weapons, sensors and computers that will fight the defensive war rather than the transportation, support and logistics that will create and sustain it. Congress, however, should be wary of such optimistic assessments. If the past is any guide, administrative and sociological hurdles become as difficult to overcome as the technological ones.

4. Administration

We were impressed with the SDI officials, managers, scientists and engineers who briefed us. From General Abrahamson on down, they displayed an unusually high degree of professionalism and dedication to the mission they have been assigned. Nevertheless, some problems appear to be surfacing in the management and administration of SDI.

There appears to be some duplication of services among the laboratories and the military agencies working on SDI research. For example, both the Army and Air Force have their own systems, battle management, and support offices. For the moment, it is open to question how harmful or helpful this duplication is. In the future, however, they will have to be consolidated for greater efficiency and effectiveness.

Service rivalry, particularly between the Army and the Air Force is beginning to creep into the SDI program. This situation will get worse before it gets better. There also appears to be some tension growing between the SDI organization and the services and the laboratories. This tension may be exacerbated by the large increase in SDI's funding, which the services and labs complain are resulting in less and in some cases inadequate funding available for other vital military research.

There is also a growing rivalry among the national laboratories researching SDI. In some respects this rivalry can be healthy. However, it can be detrimental, SDI scientists warn, when it leads to labs making unsubstantiated claims of success for their own work or unfair criticisms of the work of other labs. For example, some SDI scientists were deeply concerned over high officials at the Livermore Laboratory making inflated claims about the X-ray laser's capabilities. The scientists, including some at Livermore, also were deeply concerned that inflated claims by lab and SDI officials of the research's progress would adversely affect the credibility of the laboratories.

Arms Control

The briefings and interviews conducted for this report revealed two additional points that must be considered in assessing the value of arms control for SDI.

1. Some of SDI's supporters have maintained that the 1972 ABM Treaty is no longer in the United State's national security interest and is presently holding back SDI research. The authors could find no credible evidence of SDI research at this early stage being adversely affected by the ABM Treaty. SDI, no doubt could conduct early tests and experiments that would clearly violate the ABM Treaty. The case has not been made, however, that these experiments would be necessary at this point for the overall progress of the research.

On the contrary, a violation at this point could do serious harm to U.S. national security and the SDI program. As one senior officer deeply involved in SDI research admitted, "It is not in our interest to violate the ABM Treaty at this point because of the Soviet breakout capability."

Intelligence analysts estimate it would take about four years for the Soviet Union to break out of the ABM Treaty and expand its missile defense system in an attempt to cover a full range of military targets. However, as the SDI program progresses, the time it would take the U.S. to respond to a Soviet breakout with a similar deployment stretches out because of the shift in resources in SDI from near-term technologies to defend hardened military sites such as missile silos to far-term technologies to shield cities and other civilian targets.

This shift is in keeping with the President's goal of a comprehensive non-nuclear defense; however, as a result, "we haven't done a lot to protect our near-term options," said the senior officer. Therefore, as SDI research progresses it is in our near-term interest that both superpowers abide by the ABM Treaty, because a premature violation could result in the Soviets starting the ABM race a lap ahead of us.

2. There is also the belief among some SDI proponents that the current U.S.-Soviet strategic arms limitation agreements, particularly SALT II, are not in our national security interests. SDI officials, however, admit that the SALT limits are presently in their best interest. "I would not like to see the Soviets go beyond the SALT limits," said General Abrahamson.

The reason is simple. A U.S.-Soviet breakout of SALT only compounds the problems SDI faces in both the near and far term. It could mean a doubling of the Soviet strategic warhead threat within a decade. By the end of the century, the number of RVs under a proliferated threat might be quadrupled. (See Figure 27.)

It is generally agreed within SDI that a U.S. defensive deployment would have to proceed hand-in-hand with deep reductions in Soviet offensive nuclear forces for the defense to be truly effective. Current limitations leave a Soviet offensive nuclear arms force that would be stressing enough to U.S. strategic defense. Further Soviet increases would only only increase the problems for that defense.

President Reagan has challenged conventional notions of the value of both deterrence and arms control. It remains to be seen whether mutual assured survival can replace the present deterrence/arms control regime. For the moment, however, it is clear that any break with arms control would be damaging not only to U.S. national security, but SDI's goal as well.

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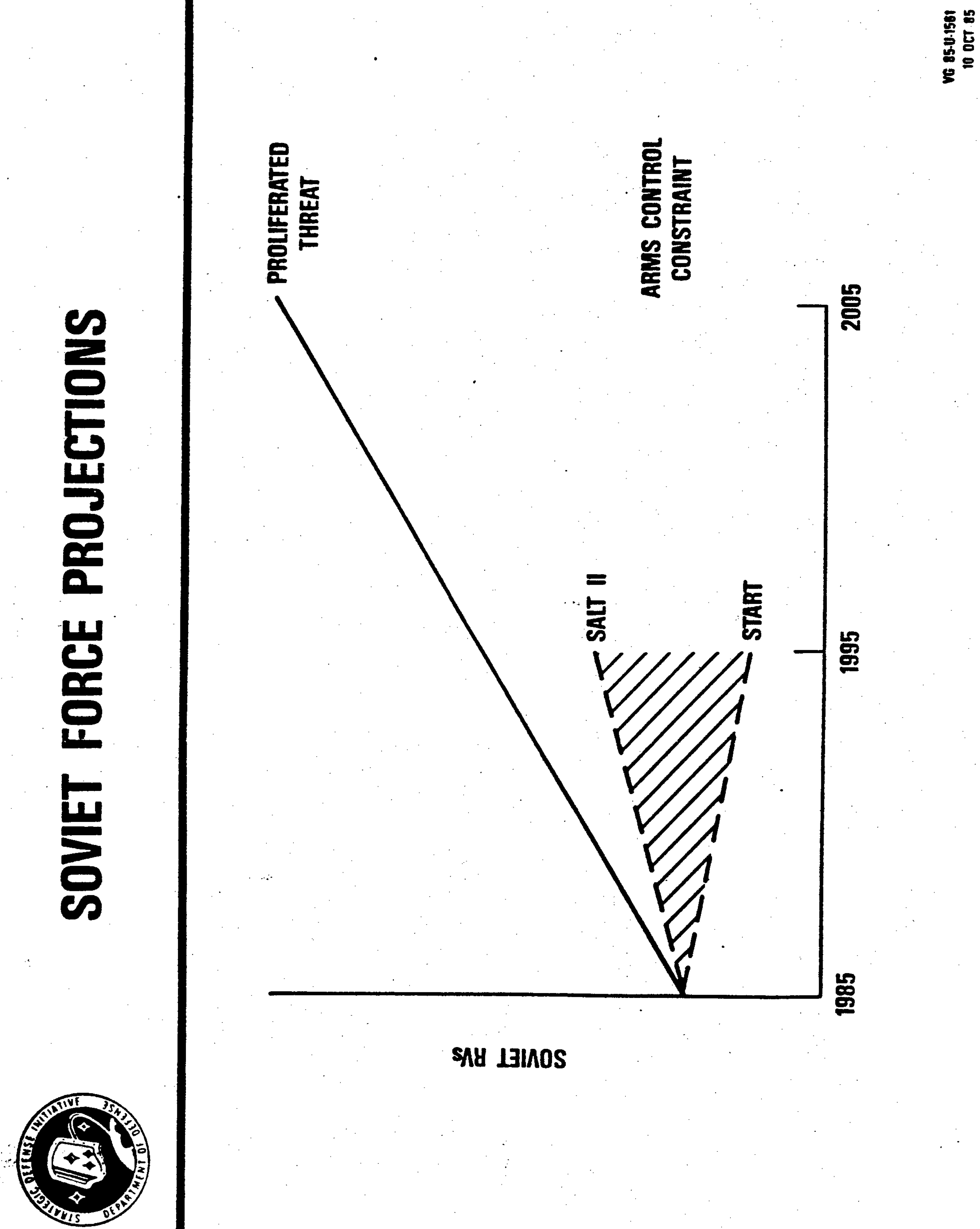
Figure 27



GLOSSARY OF TERMS AND ABBREVIATIONS

ABM	anti-ballistic missile
AOA	airborne optical adjunct
ATP	aquisition, tracking, and pointing
ATSU	accelerator test stand upgrade
BMD	ballistic missile defense
BM/C3	battle management/command, control and communications
BSTS	boost surveillance and tracking system
DARPA	Defense Advanced Research Projects Agency
DEW	directed energy weapons
DOD	Department of Defense
ENDO-NNK	endoatmospheric non-nuclear kill
EXO-NNK	exoatmospheric non-nuclear kill
ERIS	exoatmosperic reentry interceptor experiment
FEL	free electron laser
HOE	homing overlay experiment
HEDI	high endoatmospheric defense interceptor
ICBM	intercontinental ballistic missile
IR	infra red
KEW	kinetic energy weapons
LAMP	large advanced mirror program
LODE	large optics demonstration experiment
LWIR	long wavelength infrared prob
MIRCLE	mid-infrared chemical laser
SATKA	surveillance, acquisition, tracking, and kill assessment
SBKKV	space based kinetic kill vehicle

SBPB	space based particle beam
SDI	Strategic Defense Initiative
SDIO	Strategic Defense Initiative Organization
SSTS	space surveillance and tracking system
TIR	terminal imaging radar